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S I X

D I S C O U R S E S,

DELIVERED BY

SIR JOHN PRINGLE, BART.

WHEN PRESIDENT OF THE

R O Y A L S O C I E T Y;

On occasion of Six Annual Assignments of

SIR GODFREY COPLEY's MEDAL.

TO WHICH IS PREFIXED THE

L I F E O F T H E A U T H O R.

By ANDREW KIPPIS, D.D. F.R.S. and S.A.

L O N D O N :

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P R E F A C E.

SOME time before Sir John Pringle's decease, several of his friends expressed a wish that he would collect into a volume the Six Discourses he had delivered, upon occasion of so many annual assignments of Sir Godfrey Copley's Medal. This he declined doing, during his own life; but was disposed to have them published, in the manner that was requested, after his death: for which express purpose, he committed a copy of them into my hands, a few days before he set out for Edinburgh, in 1781. But, notwithstanding my authority from Sir John Pringle, as the Discourses had been originally printed

under the sanction, and by the command, of the Royal Society, I did not think myself justified in republishing them, without the permission of that learned Body. Accordingly, I applied to Sir Joseph Banks, who took up the matter with great readiness and politeness; and, laying it before the Council, it was unanimously agreed that I should have their consent and approbation in the execution of my design. For the condescension and favour thus obligingly shewn to me, both by the President and the Council, I here desire their acceptance of my grateful acknowledgments.

Many of the materials from which the following Narrative is composed, have been furnished me by Sir John Pringle's family and friends. In this respect, I am particularly obliged to

the attention and care of Sir James Pringle, and Dr. Hope of Edinburgh. Other circumstances have been collected from several gentlemen in London; and especially from Dr. William Watson, Dr. Richard Saunders, and Mr. Stevenson. With the latter part of our Author's Life I was myself well acquainted; having been honoured with his friendship for nearly ten years before his decease. When the succeeding Account of him had been most of it printed off, James Boswell Esq. was so good as to favour me with a recital of various particulars, drawn from his own intimacy with Sir John Pringle, and from the information of his father, Lord Auchinleck. This communication did not come so late, but that I was able to avail myself of it, in several respects. Two things are mentioned by Mr. Boswell,

Boswell, that I had not been informed of before ; and which, therefore, could not be introduced in their proper places. One is, that Sir John Pringle, after he had studied at the University of Edinburgh, was intended for the mercantile line, and that he went to Amsterdam for that purpose ; but that his mind was turned to Physic, by accidentally hearing, at Leyden, a lecture of Boerhaave's, which struck him in a remarkable manner. The other is, that he completed his medical studies at Paris. This I suspected to be the case ; but not being assured of it, I did not choose to insert it in my Narration. Where any circumstances are taken from books, I have referred to my authorities. It will be seen that I am under some obligations to the Anecdotes of Mr. Bowyer, by my friend
Mr.

Mr. Nichols ; to whom Biography, and Biographers in general, are so much indebted.

I desire the Reader to remember, that it hath been my intention to give a Life of Sir John Pringle, with plainness and simplicity ; and not a studied panegyric. The elaborate and oratorical form of the professed Eulogium, which, on certain occasions, has its use and its beauty, I leave to the much abler men, who will undertake it at Paris ; and I shall esteem myself happy in having had it in my power to provide them with materials for their more elegant narratives. They may depend upon it, that Truth hath been my object ; and that I have said nothing concerning Sir John Pringle, which, I believe, will not be acknowledged to be just, by those who were best acquainted with his character.

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O B S E R V A T I O N S
O N T H E
D I S E A S E S O F T H E A R M Y.

By SIR JOHN PRINGLE, BART.

Late President of the Royal Society, and Physician to
their Majesties.

T H E
L I F E
O F

SIR JOHN PRINGLE, BART.

SIR JOHN PRINGLE was born at Stichel-House, in the county of Roxburgh, North Britain, on the 10th of April, 1707. His father was Sir John Pringle of Stichel, Bart. and his mother, whose name was Magdalen Eliott, was sister to Sir Gilbert Eliott of Stobs, Bart. Both the families from which he descended were very antient and honourable ones in the south of Scotland, and were in great esteem for their attachment to the religion and liberties of their country, and for their

a

piety

piety and virtue in private life. He was the youngest of several sons, three of whom, besides himself, arrived to years of maturity*. His grammatical education he received

* Robert, the eldest, succeeded to the estate and title of the family, and died, not many years since, at an advanced age. Gilbert, the second, was an officer in the army; and Walter, the third, who was brought up to the law, was Sheriff of the county of Roxburgh. Sir John Pringle of Stichel had also, by his Lady, an only daughter, Margaret, who was married to Sir James Hall, Bart. of Dunglass, and was mother to the late Sir John, and grandmother to the present Sir James Hall. Robert Pringle, Esq; a brother of the first Sir John Pringle, having quitted his native country, during the tyrannical government of King James the Second, came over with the Prince of Orange at the Revolution, and was appointed Deputy Secretary of State for Scotland. He was afterwards Secretary of War for Great Britain, and, at length, Register General of the Shipping; which post he held till his decease. In Carstairs's State-Papers, there are five letters written by him, which shew that he was a sensible and moderate man, and well versed in public affairs. He departed this life at Rotterdam, on his return to England from the Spa, on the 13th of September 1736, being eighty years of age. Another brother of the first Sir John

received at home, under a private tutor; and after having made such a progress as qualified him for academical studies, he was removed to the university of St. Andrews, where he was put under the immediate care of Mr. Francis Pringle, professor of Greek in the college, and a near relation of his father. Having continued here some years, he went to Edinburgh, in October 1727, for the purpose of studying physic, that being the profes-

Pringle, was Sir Walter Pringle, Knight, one of the senators of the college of justice at Edinburgh, under the title of Lord Newhall. This gentleman was eminently distinguished by his abilities and virtues; having been esteemed, in his time, as an ornament to the bench and the profession of the law, and as the pride and boast of his family and country. A character was drawn of him by the late Lord President Arncliffe, and published in the Scots Magazine. He died on the 13th of December, 1736; and an epitaph was written on him by Hamilton of Bangour, which is inserted in that Author's volume of poems. There is, likewise, an engraved Portrait of Sir Walter Pringle.

sion which he was now determined to follow. At Edinburgh, however, he stayed only one year, the reason of which was, that he was desirous of going to Leyden, at that time the most celebrated school of medicine in Europe. Dr. Boerhaave, who had so eminently contributed to bring that university into reputation, was considerably advanced in years; and Mr. Pringle was unwilling, by delay, to expose himself to the danger of losing the benefit of that great man's Lectures. We need not say that he here maintained the most diligent application to his medical studies, and that he made the best use of the instructions given him by the illustrious professor upon whom he attended. For Boerhaave he had a high and just respect: but it was not his disposition and character to become the implicit and systematic follower of any man, however able and distinguished. Whilst he studied at Leyden, he contracted an intimate

mate friendship with Van Swieten, who afterwards became so famous at Vienna, both by his practice and writings. Van Swieten was not only Mr. Pringle's acquaintance and fellow student at the university, but also his physician, when he happened to be seized there with a fit of sickness. Nevertheless, he did not owe his recovery to his friend's advice: for Van Swieten having refused to give him the bark, another prescribed it, and Mr. Pringle was cured. When he had gone through his proper course of studies at Leyden, he was admitted, on the 20th of July, 1730, to his Doctor of Physic's degree. His inaugural Dissertation, which, according to custom, was printed, was "de marcore senili;" and his diploma was signed, besides the other professors of the university, by Boerhaave, Albinus, and Gravefande; names of great celebrity, not

only in the medical world, but among the learned in general.

Upon quitting Leyden, Dr. Pringle settled as a physician at Edinburgh, where he gained the esteem of the magistrates of the city, and of the professors of the college, by his abilities and good conduct. Though his studies might principally be confined to his own profession, this was not so entirely the case, but that he could find time for paying a considerable degree of attention to other objects, and particularly to those highly important ones, natural religion and morality. Such, it is certain, was his known acquaintance with ethical subjects, that, on the 28th of March, 1734, he was appointed, by the magistrates and council of the city of Edinburgh, to be joint Professor of Pneumatics and Moral Philosophy with Mr. Scott, during the
said

faid Mr. Scott's life, and sole Profefſor thereof after his deceaſe; and, in confequence of this appointment, Dr. Pringle was admitted, on the ſame day, a member of the univerſity. In diſcharging the duties of this new employment, his text book was PUFFENDORFF *De Officio Hominiſ et Civis*; and agreeably to the method he purſued through life, of making fact and experiment the baſis of ſcience, he recommended much to his pupils Lord Bacon's works, and particularly the *Novum Organum* of that Father of true Philoſophy. Beſides this, he annually delivered ſeveral lectures on the immateriality and immortality of the ſoul; ſubjects that fell properly within his province, and which were not a little diſcuſſed at that period,

Dr. Pringle continued in the practice of phyſic at Edinburgh, and in performing

the obligations of his professorship, till 1742, when he was appointed physician to the Earl of Stair, who then commanded the British army. For this appointment he was chiefly indebted to his friend Dr. Stevenson, an eminent physician at Edinburgh, who had an intimate acquaintance with Lord Stair.

By the interest of this nobleman, Dr. Pringle was constituted, on the 24th of August 1742, physician to the military hospital in Flanders; and it was provided in the commission, that he should receive a salary of twenty shillings a-day, and be entitled to half pay for life. He did not, on this occasion, resign his professorship of Moral Philosophy. The university permitted him to retain it, and Messrs. Muirhead and Cleghorn were allowed to teach in his absence. The same indulgence was granted him,

him, from year to year, as long as he continued to request it.

The eminent attention which Dr. Pringle paid to his duty as an army physician, is a matter that requires no enlargement in this place. It is a fact so generally known, and so universally acknowledged, that it cannot admit of a debate or a doubt ; and were there no other testimony, it would be amply apparent from every page of his Treatise on the Diseases of the Army. One thing, however, deserves particularly to be mentioned, as it is highly probable that it was owing to his suggestion. It had hitherto been usual, for the security of the sick, when the enemy was near, to remove them a great way from the camp ; the consequence of which was, that many were lost before they came under the care of the physicians. The Earl of Stair, being sensible of this evil, proposed to the
Duke

Duke de Noailles, when the army was encamped at Aschaffenburg, in 1743, that the hospitals on both sides should be considered as sanctuaries for the sick, and mutually protected. The French general, who was distinguished for his humanity, readily agreed to the proposal, and took the first opportunity of shewing a proper regard to his engagement. For, after the battle of Dettingen, when the British hospital was at Feckenheim, a village upon the Maine, at a distance from the camp, the Duke de Noailles, having occasion to send a detachment to another village upon the opposite bank, and apprehending that this might alarm the sick, he sent to acquaint them, that he had given express orders to his troops not to disturb them. This agreement was strictly observed on both sides during that campaign*.

* Preface to the Observations on the Diseases of the Army, p. 8. Seventh edition.

At the battle of Dettingen, Dr. Pringle was in a coach with Lord Carteret during the whole time of the engagement, and the situation they were placed in was dangerous. They had been taken at unawares, and were kept betwixt the fire of the line in front, a French battery on the left, and a wood full of hussars on the right. The coach was occasionally shifted, to avoid being in the eye of the battery.

Soon after this event, Dr. Pringle met with no small affliction in the retirement of his great friend, the Earl of Stair, from the army. He offered to resign with his noble patron: but that generous and liberal minded commander not permitting him to think of it for a moment, he was obliged to content himself with testifying his respect and gratitude to his Lordship, by accompanying him forty miles on his return

turn to England; after which he took leave of him with the utmost regret.

But though Dr. Pringle was thus deprived of the immediate protection of a nobleman who knew and esteemed his worth, his conduct in the duties of his station procured him effectual support. He attended the army, in Flanders, through the campaign of 1744, and so powerfully recommended himself to the Duke of Cumberland, that, in the spring following, on the 11th of March, he had a commission from his Royal Highness, appointing him Physician General to his Majesty's forces in the Low Countries, and parts beyond the seas: and on the next day he received a second commission from the Duke, by which he was constituted Physician to the Royal hospitals in the same countries.

Hitherto Dr. Pringle had not been certain whether he might not find reason to
return

return to the duties of his station at Edinburgh, and to his medical practice in that city. But no sooner was he assured of the promotions we have just mentioned, than he thought proper to resign his Professorship of Pneumatics and Moral Philosophy. His letter to this purpose, addressed to Dr. Wishart, Principal of the college, is dated on the 5th of March, 1744-5; in which, with many expressions of gratitude, respect, and affection to the university, he declares that he gives up his charge without condition or limitation.

In 1745, he was with the army in Flanders, but was recalled from that country, in the latter end of the year, to attend the forces which were to be sent against the Rebels in Scotland. At this time he had the honour of being chosen a Fellow of the Royal Society. The election was on the 30th of October, and the

Society had reason to be pleased with the addition of a member, who was earnestly devoted to the pursuit of science in general, and who had the reputation and interest of natural and experimental philosophy particularly at heart. How well he merited the distinction conferred upon him, will hereafter appear.

Dr. Pringle, at the beginning of the year 1746, accompanied, in his official capacity, the Duke of Cumberland in his expedition against the Rebels, and remained with the forces, after the battle of Culloden, till their return to England, in the middle of August. We do not find that he was in Flanders during any part of that year. In 1747 and 1748, he again attended the army abroad; and in the autumn of 1748, he embarked with the forces for England, upon the conclusion of the treaty of Aix la Chapelle. From that
time

time he principally resided in London, where, from his known skill and experience, and the reputation he had acquired, he might reasonably expect to succeed as a physician. It was to his knowledge, his application, and his attention alone, that he trusted for making his way in the metropolis. If any little artifices are ever made use of, in the city of London, to excite popularity, and to promote medical practice, Dr. Pringle was the last man to adopt such artifices. If he could not have built his success on the basis of substantial merit, he would not have succeeded at all. We cannot but think that such a conduct is highly deserving of approbation and applause. In every profession of life, there is no satisfaction that is equal to the consciousness of inward worth, and of a mind superior to the various contrivances for obtaining the notice and favour of mankind

kind

kind, to which insufficiency, vanity, or covetousness sometimes have recourse.

In the month of April, 1749, Dr. Pringle was appointed Physician in Ordinary to his Royal Highness the Duke of Cumberland *. In 1750, he published, in a letter to Dr. Mead, "Observations on the Jail or Hospital Fever." This piece, which passed through two editions, and was occasioned by the jail-distemper that broke out at that time in the city of London, was well received by the medical world, though he himself afterwards considered it as having been hastily written. After supplying some things that were omitted, and rectifying certain mistakes that were made in it, he included it in his grand work on the Diseases of the Army, where it con-

* Gent. Mag. Vol. xix. p. 189.

stitutes the seventh chapter of the third part of that Treatise.

It was in the same year, that Dr. Pringle began to communicate to the Royal Society his famous ‘ Experiments upon Septic and ‘ Antiseptic Substances, with Remarks relating to their Use in the Theory of ‘ Medicine.’ These Experiments, which comprehended several Papers, were read at different meetings of the Society ; the first in June, and the two next in the November following : three more in the course of the year 1751 ; and the last, in February, 1752. Only the three first Numbers were printed in the Philosophical Transactions ; the reason of which was, that Dr. Pringle had subjoined the whole, by way of Appendix, to his ‘ Observations on the Diseases of the Army ;’ for it is a general rule with the Royal Society, to insert, in their Journals, none of those Papers which, having

b been

been read before them, are afterwards published by the Authors themselves.

The Experiments upon Septic and Antiseptic Substances, which have accompanied every subsequent edition of the treatise just mentioned, procured for our ingenious Physician the honour of Sir Godfrey Copley's gold medal. Besides this, they gained him a high and just reputation, as an experimental philosopher; and, perhaps, have not a little contributed to promote that ardent spirit of enquiry into the chemical powers and properties of Nature, which hath lately been productive of such wonderful discoveries.

But though the Papers now specified were Dr. Pringle's chief communications to the Royal Society; the communications that were the most important in themselves, and on which his philosophical fame was principally

principally founded ; they were not the sole evidences of his sollicitude, whilst only a private member of that learned Body, to carry on the purposes of its institution. Not again to resume the subject, we shall here mention several instances besides of his attention to Natural Knowledge, which have occurred to us, in looking over the Philosophical Transactions, and other publications.

In February, 1753, he presented to the Society an ‘ Account of several Persons
‘ seized with the Gaol Fever by working
‘ in Newgate, and of the Manner by which
‘ the Infection was communicated to one
‘ entire Family.’ This is a very curious Paper ; and it was deemed of such importance by the excellent Dr. Stephen Hales, that he requested the Author’s permission to have it published, for the common good of the kingdom, in the Gentleman’s Maga-

zine; where it was accordingly printed, previously to its appearance in the Transactions*. Dr. Pringle's next communication was, 'A remarkable Case of Fragility, Flexibility, and Dissolution of the Bones †.' In the forty-ninth volume of the Transactions, we meet with accounts which he had given of an earthquake felt at Brussels; of another at Glasgow and Dunbarton ‡; and of the agitation of the waters, on the first of November, 1756, in Scotland and at Hamburgh §. The fifteenth volume contains Observations, by him, on the Case of Lord Walpole, of Woolterton; and a Relation of the Virtues of Soap, in dissolving the Stone, as experienced by the Reverend

* Gentleman's Magazine, vol. xxiii. p. 71—74. Philosophical Transactions, vol. xlviii. part i. p. 42—54.

† Ibid. p. 297—301.

‡ The greater part of the Paper is by Dr. Whyt.

§ Vol. xlix. part ii. p. 509—511. 546, 547. 550, 551.

Mr. Matthew Simfon *. The next volume is enriched with two of the Doctor's Articles, of considerable length, as well as value. In the first, he hath collected, digested, and related the different accounts that had been given of a very extraordinary fiery meteor, which appeared on Sunday, the 26th of November 1758, between eight and nine at night; and, in the second, he hath made a variety of remarks upon the whole, wherein is displayed no small degree of philosophical sagacity †. It would be tedious to mention the various Papers, which, both before and after he became President of the Royal Society, were transmitted through his hands. The merit of these Papers must principally and distinctively rest with the Gentlemen by whom they were drawn up; though there

* Vol. l. part. i. p. 205—209. 219. 221.

† Vol. li. part i. p. 218—274.

can be no doubt, but that some of them were prepared in consequence of his particular request, and might probably derive a considerable portion of their accuracy and perfection from the hints which he had suggested. Besides his communications in the Philosophical Transactions, he wrote, in the Edinburgh Medical Essays, volume the fifth, an Account of the Success of the *Vitrum ceratum Antimonii*.

On the 14th of April, 1752, Dr. Pringle married Charlotte, the second daughter of Dr. Oliver, an eminent physician at Bath, and who had long been at the head of his profession in that city. This connection did not last long; the lady dying in the space of a few years.

Nearly about the time of his marriage, Dr. Pringle gave to the Public the first edi-

tion of his ‘ Observations on the Diseases
 ‘ of the Army.’ It was reprinted, in the
 year following, with some additions. To
 the third edition, which was greatly im-
 proved from the farther experience the
 Author had gained by attending the camps,
 for three seasons, in England, an Appendix
 was annexed, in answer to some remarks
 that Professor De Haen, of Vienna, and
 M. Gaber, of Turin, had made on the
 Work. The like attention was paid to the
 improvement of the Treatise, in every sub-
 sequent edition. From more mature re-
 flection, from the additional experience
 afforded by his private practice, and from
 his intercourse with the medical gentlemen
 who had been employed in the hospitals
 abroad, in different climates, during the
 late war,—Dr. Pringle had an opportunity
 of expressing, with greater confidence, some
 of his former observations; and of omit-
 ting others, which he had advanced with-

out sufficient foundation. The work is divided into three parts; the first of which, being principally historical, may be read with pleasure by every gentleman. The latter parts lie more within the province of physicians. They alone are the best judges of the merit of the performance; and to its merit the most decisive and ample testimonies have been given. It hath gone through seven editions at home; and, abroad, it has been translated into the French, the German, and the Italian languages. Scarcely any medical writer hath mentioned it, without some tribute of applause. Ludwig, in the second volume of his ‘*Commentarii de Rebus in Scientia Naturali et Medica gestis*,’ speaks of it highly; and gives an account of it, which comprehends sixteen pages. The celebrated and eminent Baron Van Haller, in his *Bibliotheca Anatomica* *, with a particular reference to the

* Tom. ii. p. 235.

treatise we are speaking of, files the author
 ‘ Vir illustris — de omnibus bonis artibus
 ‘ benè meritus,’

It would be easy to produce a number of encomiums of a similar kind; but it is the less necessary to multiply them, as the excellence of Dr. Pringle’s Work is so generally acknowledged. It is allowed to be a classical book in the physical line; and that it hath placed the Writer of it in a rank with the famous Sydenham. Like Sydenham, too, he hath become eminent, not by the quantity, but the value of his productions; and hath afforded a happy instance of the great and deserved fame, which may sometimes arise from a single performance. If it would not carry us too far out of our way, it might be an amusing speculation, to consider the different paths which great men have pursued in their literary course; and how happily some few,

both among the ancients and the moderns, have attained a high degree of glory, by only one, or, at least, a small number of compositions.

The reputation that Dr. Pringle gained by his ‘ Observations on the Diseases of the Army,’ was not of a kind which is ever likely to diminish. He was happy in the choice of his subject, which, though it ought long ago to have been completely handled, had scarcely hitherto been touched upon ; and, though improvements will, no doubt, be made, and perhaps have been made, in the course of practice, as medical knowledge becomes more and more cultivated, the Work will always be held in esteem, as having been founded on the solid basis of experience, and not of theory. Its fate will be very different from that of many systems, which, though they have raised the fabricators of them to a
great

great temporary celebrity, have speedily sunk into oblivion, if not into contempt. Various instances might be mentioned of persons, whose hypotheses, notwithstanding their having been the applause and wonder of their day, are now, if not forgotten, totally disregarded. But we have no design of exalting our Author by other men's disgrace.

The utility of Dr. Pringle's Treatise was of still greater importance than its reputation. From the time that he was appointed a Physician to the Army, it seems to have been his grand object, to lessen, as far as lay in his power, the calamities of war: nor was he without considerable success in his noble and benevolent design. It cannot be doubted, but that the treatment he hath recommended, from his own observation and experience, hath been adopted by the able and judicious practitioners who have succeeded

fulfilled him ; and that hence many lives have been preserved, which would otherwise have been lost to the community.

The benefits which may be derived from our Author's Observations on the Diseases of the Army, are not solely confined to gentlemen of the medical profession. Commanders may learn from them, and especially from the concluding chapter of the second part of the Treatise, to determine, with some degree of certainty, what force may, at any time, be relied upon for service ; the effects of short or long campaigns upon the health of the soldiers ; the difference between taking the field early, and going late into winter quarters ; with other calculations, founded upon such materials as are furnished by war. General Melville, a gentleman who unites with his military abilities, the spirit of philosophy, and the spirit of humanity, was enabled, when
Governor

Governor of the Neutral Islands, to be singularly useful, in consequence of the instructions he had received from Dr. Pringle's book, and from personal conversation with him. By taking care to have his men always lodged in large, open, and airy apartments; and by rapidly shifting their quarters from the low, damp, and marshy parts of the country, to the dry and hilly grounds, so as never to let his forces remain long enough in the swampy places, to be injured by the noxious air of such places, the General was the happy instrument of saving the lives of seven hundred soldiers. A more honourable testimony cannot be given to the utility of the principles and rules which had been laid down by our Author.

In 1753, Dr. Pringle was chosen one of the Council of the Royal Society. Though he had not, for some years, been called
abroad,

abroad, he still held his place of Physician to the Army; and, in the war that began in 1755, attended the camps, in England, during three seasons. This enabled him, from farther experience, to correct some of his former observations, and to give additional perfection to the third edition of his great Work. In 1758, he entirely quitted the service of the Army; and being now determined to fix wholly in London, he was admitted a Licentiate of the College of Physicians, on the fifth of July, in the same year. The reason why this matter was so long delayed, might probably be, his not having hitherto come to a final resolution, with regard to his settlement in the Metropolis.

After the accession of King George the Third to the throne of Great Britain, Dr. Pringle was appointed, in 1761, Physician to the Queen's Household; and this honour

nour was succeeded, by his being constituted, in 1763, Physician Extraordinary to her Majesty. On the twelfth of April, in the same year, he had been chosen a Member of the Academy of Sciences at Haarlem; and, on the twenty-fifth of June following, he was elected a Fellow of the Royal College of Physicians, London. In the succeeding November, he was returned on the ballot, a second time, one of the Council of the Royal Society; and, in 1764, on the decease of Dr. Wollaston, he was made Physician in Ordinary to the Queen. On the thirteenth of February 1766, he was elected a foreign member, in the physical line*, of the Royal Society of Sciences at Goettingen; and, on the fifth of June, in that year, his Majesty was graciously pleased to testify his sense of Dr. Pringle's abilities and merit, by raising him to the dignity of a Baronet of Great Britain.

* Collega exterus Classis Physicæ.

On the eighteenth of July 1768, Sir John Pringle was appointed Physician in Ordinary to her late Royal Highness the Princess Dowager of Wales; to which office a salary was annexed of one hundred pounds a year. In 1770, he was chosen, a third time, into the Council of the Royal Society; as he was, likewise, a fourth time, for the year 1772. Upon the thirtieth of November, in that year, in consequence of the death of James West Esquire*, he was elected

* James West Esq. had succeeded the Earl of Morton, as President of the Society. He was the son of Richard West Esquire; and is understood to have been descended from Thomas West, Lord Delawar, who lived in the reign of King James the First. Mr. James West was educated at Baliol College, Oxford; where he was admitted to the degree of Master of Arts, on the twenty-third of June, 1726. In 1741, he was chosen Representative of the Borough of St. Albans; which borough he continued to serve, during several parliaments. Being appointed one of the Joint Secretaries of the Treasury, he remained in that office many years; having held it till 1762. When, in 1765, his old friend and patron, the Duke of Newcastle,

electd president of that illustrious and learned Body. His election to this high station, though he had so respectable a

caste, reverted to some degree of power, by being constituted, during the short period of the Rockingham administration, Lord Privy Seal, his Grace obtained for him an annual pension of two thousand pounds. Mr. West was an early member of the Society of Antiquaries, and at length one of its Vice-Presidents. Having been chosen a Fellow of the Royal Society, he became, in a course of time, Treasurer to that Body; and, at last, as we have already seen, was raised to the Chair. Though he was a man of general learning, we do not recollect that he was eminently distinguished by his acquaintance with Philosophical or Natural Knowledge. It admits of no doubt, that, in this respect, he was greatly excelled by most of the Presidents who went before him, and by those who were his successors. As a Collector, he had great merit. He had a large and valuable collection of manuscripts relative to the History of England, which was sold, after his decease, to the Earl of Shelburne. His books, his prints and drawings, his coins and medals, his pictures, and other miscellaneous articles and curiosities, were all of them disposed of by auction, in 1773: and the sale of the whole employed fifty-five days. Mr. West died on the second of July, 1772. (Nichols's Anecdotes of Mr. Bowyer, p. 101, 102.)

character, as the late Sir James Porter, for his opponent, was carried by a very considerable majority. This was undoubtedly the highest honour that Sir John Pringle ever received ; an honour with which his other literary distinctions could not be compared. He was fully sensible of the eminent mark of esteem which the Royal Society had conferred upon him ; and he was, at the same time, deeply convinced, that his new situation was not only a situation of dignity, but of the greatest trust and importance. Accordingly, it was his determination to discharge the duties of it with all the attention, assiduity, and zeal, of which he was capable.

It was at a very auspicious time that Sir John Pringle was called upon to preside over the Royal Society. A wonderful ardour for philosophical science, and for the advancement

ment of Natural Knowledge, had, of late years, displayed itself through Europe, and had appeared with particular advantage in our own country. Britons, to say the least of them, had had their full share in the discoveries of magnetism and electricity, in botanical enquiries and researches, and in the pursuit of other important objects. The spirit of experimental investigation into every part and property of Nature, was high; and nothing could be more agreeable to the genius of Sir John Pringle, than to cherish such a spirit. He endeavoured to do it by all the methods that were in his power; and he happily struck upon a new way to distinction and usefulness, by the discourses which were delivered by him on the annual assignment of Sir Godfrey Copley's Medal.

This gentleman had originally bequeathed five guineas, to be given, at each anni-

versary meeting of the Royal Society, by the determination of the President and Council, to the person who had been the author of the best Paper of Experimental Observations for the year past. In process of time, this pecuniary reward, which could never be an important consideration to a man of an enlarged and philosophical mind, however narrow his circumstances might be, was changed into the more liberal form of a gold medal ; in which form it is become a truly honourable mark of distinction, and a just and laudable object of ambition. It was, no doubt, always usual with the President, on the delivery of the Medal, to pay some compliment to the gentleman on whom it was bestowed ; but the custom of making a set speech on the occasion, and of entering into the history of that part of philosophy to which the experiments related, was first introduced by Mr. Martin Folkes. The Discourses, how-

ever, which he and his fucceffors delivered, were very fhort, and were only inferted in the minute-books of the Society. None of them had ever been printed before Sir John Pringle was raifed to the Chair. The firft fpeech that was made by him being much more elaborate and extended than ufual, the publication of it was defired; and with this request it is faid that he was the more ready to comply, as an abfurd account of what he had delivered had appeared in a newfpaper.

Sir John Pringle was very happy in the fubject of his primary Difcourfe. The difcoveries in magnetifm and electricity had been fucceeded by the enquiries into the various fpecies of air. In thefe enquiries, Dr. Priestley, who had already greatly diftinguifhed himfelf by his electrical experiments, and his other philofophical purfuits and labours, took the principal lead. A

Paper of his, entitled, ‘ Observations on ‘ different Kinds of Air,’ having been read before the Society in March 1772, was adjudged to be deserving of the Gold Medal; and Sir John Pringle embraced with pleasure the occasion of celebrating the important communications of his Friend, and of relating, with accuracy and fidelity, what had previously been discovered upon the subject. At the close of the speech, he earnestly requested Dr. Priestley to continue his liberal and valuable enquiries; and we need not say how eminently he hath fulfilled this request. The astonishing discoveries he hath since made, and is still making, have set his name far above all praise.

It was not, we believe, intended, when Sir John Pringle’s first speech was printed, that the example should be followed: but the second Discourse was so well received
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by the Royal Society, that the publication of it was unanimously requested. Both the Discourse itself, and the subject on which it was delivered, merited such a distinction. The composition of the second speech is evidently superior to that of the former one; Sir John having probably been animated by the favourable reception of his first effort. His account of the Torpedo, and of Mr. Walfsh's ingenious and admirable experiments relative to the electrical properties of that extraordinary fish, is singularly curious. The whole Discourse abounds with ancient and modern learning, and exhibits Sir John Pringle's knowledge in Natural History, as well as in Medicine, to great advantage.

The third time that he was called upon to display his abilities at the delivery of Sir Godfrey Copley's Medal, was on an eminently beautiful and important occasion.

This was no less than Mr. (now Dr.) Maskelyne's successful attempt completely to establish Sir Isaac Newton's system of the universe, by his ' Observations made on ' the Mountain Schehallien, for finding its ' Attraction.' Sir John Pringle laid hold of this opportunity to give a perspicuous and accurate relation of the several hypotheses of the ancients, with regard to the revolutions of the heavenly bodies, and of the noble discoveries with which Copernicus enriched the astronomical world. He then traces the progress of the grand principle of Gravitation, down to Sir Isaac's illustrious confirmation of it ; to which he adds a concise narrative of Messrs. Bouguer's and Condamine's experiment at Chimboraco, and of Mr. Maskelyne's at Schehallien. If any doubts still remained, with respect to the truth of the Newtonian System, they are now totally removed. Dr. Maskelyne, who has otherwise largely contributed

tributed to the advancement of philosophical science, hath had the singular honour of establishing so firmly the doctrine of universal attraction by this finishing step of analysis, that the most scrupulous can no longer hesitate to embrace a principle that gives life to astronomy, by accounting for the various motions and appearances of the hosts of heaven.

Sir John Pringle had reason to be peculiarly satisfied with the subject of his fourth Discourse; that subject being perfectly congenial to his disposition and studies. His own life had been much employed in pointing out the means which tended not only to cure, but to prevent, the diseases of mankind; and it is probable, from his intimate friendship with Captain Cook, that he might suggest to that sagacious commander some of the rules which he followed, in order to preserve the health of the crew

crew of his Majesty's ship the Resolution, during her voyage round the world. Whether this was the case, or whether the method pursued by the Captain, to attain so salutary an end, was the result alone of his own reflections, the success of it was astonishing. Captain Cook, with a company of an hundred and eighteen men, performed a voyage of three years and eighteen days, throughout all the climates, from fifty-two degrees North to seventy-one degrees South, with the loss of only one man by sickness. By precautions equally wise and simple, he rendered the circumnavigation of the globe, so far as health is concerned, quite a harmless object. It is no wonder that Sir John Pringle should celebrate, with affection, the conduct of his friend; who, besides his admirable skill in preserving the lives and health of his sailors, had not only discovered, but surveyed, vast tracts of new coasts; had dispelled the
 illusion

illusion of a *Terra Australis Incognita*, and fixed the bounds of the habitable earth, as well as those of the navigable ocean, in the Southern hemisphere. Indeed, no one could be more justly entitled to applause than that man, who, independently of his other claims to distinction, had been able, by the practice of a few plain rules, resulting from the union of good sense, humanity, and experience, to render himself an eminent benefactor to his fellow-creatures. Captain Cook was not present to receive the honour of the Gold Medal. He was gone out upon the voyage from which he never returned. In this last voyage, he was equally successful in maintaining the health of his men; and he determined the point, which had so long been contested, whether there is a practicable North-West passage from Europe to the East Indies. But though, in these respects, he attained the objects he had in view, it must ever be reflected

reflected upon with regret, that, in an unfortunate quarrel with the inhabitants of a remote island, the world was deprived of this great navigator, whose excellence and fame will be transmitted to the latest posterity.

Sir John Pringle, in his next annual dissertation, had an opportunity of displaying his knowledge in a way in which it had not hitherto appeared. The Discourse took its rise from the Prize Medal's being adjudged to Mr. Mudge, then an eminent surgeon at Plymouth, upon account of his valuable Paper, containing directions for making the best composition for the metals of reflecting telescopes, together with a description of the process for grinding, polishing, and giving the great speculum the true parabolic form. Sir John hath accurately related a variety of particulars, concerning the invention of reflecting telescopes,

scopes, the subsequent improvements of these instruments, and the state in which Mr. Mudge found them, when he first set about working them to a greater perfection, till he had truly realized the expectation of Sir Isaac Newton, who, above an hundred years ago, presaged that the Public would one day possess a parabolic speculum, not accomplished by mathematical rules, but by mechanical devices. From this narration our Author naturally rises, in his thoughts, to the wonders that astronomy presents to our view, and to the admirable advantages which philosophical science hath derived from the methods that have been pursued for enlarging the powers of vision.

It is impossible to pass over the subject before us, without reflecting on the great accession which has been made to astronomical knowledge, and the honour of the Society, since Sir John Pringle was President.

dent. Every reader will immediately understand that I refer to the communications of Mr. Herschel; who hath carried the magnifying power of telescopes to a height far beyond what had hitherto been expected; who hath brought to light a large number of double and triple stars; and who hath not only discovered, but ascertained without controversy, the existence of a new primary planet, beyond the orbit of Saturn, in the Solar System; to which, in honour of his Royal Patron and Benefactor, he hath given the appellation of the *Georgium Sidus*.

Sir John Pringle's sixth Discourse, to which he was led by the assignment of the Gold Medal to Mr. (now Dr.) Hutton, on account of his curious Paper, entitled, 'The Force of fired Gun-powder, and the initial velocity of Cannon-balls, de-

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‘terminated by Experiments,’ was on the theory of Gunnery. Though Sir John had so long attended the army, this was probably a subject to which he had heretofore paid very little attention. We cannot, however, help admiring with what perspicuity and judgment he hath stated the progress that was made, from time to time, in the knowledge of Projectiles, and the scientific perfection to which his friend, Mr. Hutton, had carried this knowledge. As Sir John Pringle was not one of those who delighted in war, and in the shedding of human blood, he was happy in being able to shew, that even the study of Artillery might be useful to mankind; and, therefore, this is a topic which he hath not forgotten to mention.

Here ended our Author’s Discourses upon the delivery of Sir Godfrey Copley’s Medal. If he had continued to preside in
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the Chair of the Royal Society, he would, no doubt, have found other occasions of displaying his acquaintance with the history of philosophy. But the opportunities which he had of signalizing himself in this respect, were important in themselves, happily varied, and sufficient to gain him a solid and lasting reputation. Perhaps it would not be desirable that publications of such a nature should be very numerous; since, by that means, they might lose, by degrees, their novelty, their utility, and their acceptance. We do not, therefore, think that, in this particular view, Sir John Pringle ought to be considered as a model to his successors. It is best that each President should distinguish himself in that way which is peculiarly suited to his own pursuits and studies; for thus, every valuable object being regarded in its turn, the honour of the Society, and the interests of philosophical and natural knowledge,

knowledge, will most effectually be promoted.

The merit of the Papers that were communicated to the Royal Society, whilst Sir John Pringle presided over it, was not confined to those alone which were honoured with the assignment of the Gold Medal. Many of the Members distinguished themselves in the same period, as is evident from a survey of the Transactions; and many names might be mentioned with applause: but it would carry us far out of our way to specify all of them; and it would be too delicate a task, to single out some few, to the exclusion of others. Indeed, the prosperous state in which the Royal Society has long subsisted, and in which it continues to subsist, must be reflected upon with pleasure by every lover of philosophical science.

Several marks of literary distinction, as we have already seen, had been conferred upon Sir John Pringle, before he was raised to the President's Chair. But, after that event, they were bestowed upon him in great abundance: and, not again to resume the subject, I shall here collect them together.

Previously, however, to these honours (excepting his having been chosen a Fellow of the Society of Antiquaries, London), he received the last promotion that was given him in his medical capacity; which was, his being appointed, on the fourteenth of November, 1774, Physician Extraordinary to his Majesty. In the year 1776, he was enrolled in the list of the members of no less than four learned Bodies. These were, the Royal Academy of Sciences at Madrid; the Society, at Amsterdam, for the Promotion of Agriculture; the Royal Academy

Academy of Medical Correspondence at Paris; and the Imperial Academy of Sciences at St. Petersburg. The times of Sir John Pringle's election into these eminent societies, according to the order in which I have mentioned them, were on the twelfth of February, in the month of September, and on the twenty-eighth and twenty-ninth of December. Upon the last occasion, he was honoured with the following Letter from Monsieur Euler; which hath been selected, out of many others of a similar nature, as an evidence of the regard and esteem wherein he was held by eminent foreigners.

‘ MONSIEUR,

‘ **L'** Academie Imperiale des Sciences
 ‘ vient de vous recevoir au nombre
 ‘ des ses Affociés étrangers, elle a voulu
 ‘ vous donner par là, Monsieur, un té-
 d 2 ‘ moignage

‘ moignage public du grand cas qu’elle fait
 ‘ déjà depuis long tems des vos travaux, et
 ‘ que vous meritez à tant de titres. Mais
 ‘ ce que réleve encore d’avantage cette re-
 ‘ ception, et ce qui est une distinction trop
 ‘ marqué pour ne pas vous en faire l’ob-
 ‘ servation, c’est que votre aggregation a
 ‘ été proclamée le jour de l’assemblée so-
 ‘ lemnelle, par laquelle l’Academie a célé-
 ‘ bré son premier jubilé demi-séculaire,
 ‘ jour qu’elle mettra toujours au nombre
 ‘ de plus glorieux pour elle, par l’insigne
 ‘ faveur de sa Majesté le Roi de Prusse, et
 ‘ de son Altesse Imperial Monseigneur le
 ‘ Grand Duc, qui ont bien voulu con-
 ‘ sentir, qu’on les aggregat à cette com-
 ‘ pagnie.

‘ Je m’applaudis d’être dans ce moment
 ‘ chargé de vous annoncer, Monsieur, cette
 ‘ nouvelle ; et je fais, avec empressement,
 ‘ une occasion aussi favorable de vous ex-
 ‘ primer

‘ primer les sentiments de la plus parfaite
 ‘ considération, avec lesquels j’ai l’honneur
 ‘ d’être, Monsieur,

‘ Votre, &c.

(Signed) ‘ JEAN ALBERT EULER*.’

St. Petersburg,
 Jan. 10, 1777.

On

* SIR,

‘ **T**HE Imperial Academy of Sciences, being de-
 ‘ sirous of giving a public testimony of the high
 ‘ esteem which it has for your learned labours, and of
 ‘ its sense of your services to the republic of letters,
 ‘ hath admitted you into the number of its foreign
 ‘ Members. Your reception into this Body has also
 ‘ been distinguished by one circumstance, too remark-
 ‘ able, and too honourable for you, to escape observa-
 ‘ tion. Your admission was publicly announced on a
 ‘ day of peculiar solemnity; on the day in which the
 ‘ Academy celebrated its first jubilee, on account of
 ‘ its having subsisted half a century; and, at the same
 ‘ time, when the Academy had the honour of re-
 ‘ ceiving into the number of its Members his Majesty
 ‘ the King of Prussia, and his Imperial Highness the
 ‘ Grand Duke.

‘ I am extremely happy, Sir, to be appointed to
 ‘ communicate to you this information; and gladly

On the fifth of July, 1777, Sir John Pringle was nominated, by his Serene Highness the Landgrave of Hesse, an honorary Member of the Society of Antiquaries at Cassel. In 1778, he succeeded the celebrated Linnæus, as one of the foreign Members of the Royal Academy of Sciences at Paris. This honour is extended by that illustrious Body only to eight persons, on which account it is justly esteemed a most eminent mark of distinction; and we believe there have been few or no instances, wherein it hath been conferred on any other than men of great and acknowledged abilities and reputation. On the eleventh of October, in the same year, our Author was chosen a Member of the Medical Society at Hanau. In the succeed-

‘ embrace this favourable opportunity of expressing
 ‘ those sentiments of the most perfect regard, with
 ‘ which I have the honour to be, Sir,

St. Petersburg,
 Jan. 10, 1777.

Your &c.

JEAN ALBERT EULER.

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ing year, on the twenty-ninth of March, he was elected a foreign Member of the Royal Academy of Sciences and Belles Lettres at Naples. The last testimony of respect which was, in this way, bestowed upon Sir John Pringle, was his being admitted, in 1781, into the number of the Fellows of the newly erected Society of Antiquaries at Edinburgh. The particular design of the Society is to investigate the History and Antiquities of Scotland: and, from the known characters and literature of the gentlemen who compose it, there can be little doubt, but that the end they have in view will successfully be accomplished. Of this there is the greater reason to be confident, as I understand, with pleasure, that the destruction of the Scottish records, by the cruel policy of king Edward the First, was not so universal, or so general, as hath commonly been supposed.

It was at a late period of life, when Sir John Pringle was in the sixty-sixth year of his age, that he was chosen to be President of the Royal Society. Considering, therefore, the extreme attention that was paid by him to the various and important duties of his office, and the great pains he took in the preparation of his Discourses, it was natural to expect that the burthen of his honourable station should grow heavy upon him in a course of time. This burthen was increased not only by the weight of years, but by the accident of a fall in the area of the back part of his house, from which he received considerable hurt, and which, in its consequences, affected his health, and weakened his spirits. Such being the state of his body and mind, he began to entertain thoughts of resigning the President's Chair. It hath been said likewise, and believed, that he was much hurt by the disputes introduced into the
Society,

Society, concerning the question, whether pointed or blunted electrical conductors are the most efficacious in preserving buildings from the pernicious effects of lightning. Of this matter the present Writer of his Life can assert nothing from personal knowledge : for though he was then in the habit of a strict intimacy with Sir John Pringle, he never heard from him any suggestion of the kind that has been mentioned. Perhaps Sir John Pringle's declining years, and the general state of his health, will form sufficient reasons for his resignation. His intention, however, was disagreeable to many of his friends, and to many distinguished Members of the Royal Society. Accordingly, they earnestly solicited him to continue in the Chair ; but, his resolution being fixed, he resigned it at the Anniversary Meeting in 1778. Joseph Banks Esq. (now Sir Joseph Banks, Bart.) was unanimously elected President in his room ;

room; a gentleman in the prime and vigour of his life, who had eminently distinguished himself by his acquaintance with Natural History; who had sailed round the globe, and performed other voyages, in pursuit of that branch of science; who is preparing, at an immense expence and labour, the noblest and most splendid botanical Work, which hath ever been presented to the Public; and who hath amply justified the choice that was made of him, by his attention to every part of his duty, and his assiduous concern to promote the interest and honour of the Society.

Though Sir John Pringle quitted his particular relation to the Royal Society, and did not attend its meetings so constantly as he had formerly done, he still retained his literary connections in general. His house continued to be the resort of ingenious

ingenious and philosophical men, whether of his own country, or from abroad ; and he was frequent in his visits to his friends. He was held in particular esteem by eminent and learned foreigners, none of whom came to England without waiting upon him, and paying him the greatest respect. He treated them, in return, with distinguished civility and regard. When a number of gentlemen met at his table, foreigners were usually a part of the company ; and it would have been an uncommon thing not to have seen some of them at his Sunday evening conversations. I remember well, that, one night, the persons present, being eight in number, were each of them of a different nation ; if Sir John Pringle, a Scotchman, and myself, an Englishman, could be so considered. The six others consisted of a Dutchman, a German, a Frenchman, a Spaniard, an Italian, and a Russian. Though we were thus diversified

verified in country, education, modes of life, and principles of religion, no obstructions hence arose to mutual harmony, pleasure, and improvement.

Sir John Pringle's infirmities increasing, he hoped that he might receive an advantage from an excursion to Scotland, and spending the summer there; which he did in the year 1780, and principally at Edinburgh. He had probably then formed some design of fixing his residence in that city. However this may have been, he was so well pleased with a place to which he had been habituated in his younger days, and with the respect shewn him by his friends, that he purchased a house there, whither he intended to return in the following spring. When he came back to London, in the Autumn of the year above mentioned, he set about preparing to put his scheme in execution. Accordingly, having

having first disposed of the greatest part of his library, he sold his house in Pall-Mall, in April, 1781, and some few days after removed to Edinburgh. In this city he was treated, by persons of all ranks, with every mark of distinction. But Edinburgh was not now to him what it had been in early life. The vivacity of spirits, which, in the days of youth, spreads such a charm on the objects that surround us, was fled. Many, if not most, of Sir John Pringle's old friends and contemporaries, were dead; and, though some of them remained, they could not meet together with the same strength of constitution, the same ardour of pursuit, the same animation of hope, which they had formerly possessed. The younger men of eminence paid him the sincerest testimonies of esteem and regard; but it was too late in life for him to form new habits of close and intimate friendship. He found, likewise,

wife, the air of Edinburgh too sharp and cold for his frame, which had long been peculiarly sensible to the severities of weather. These evils were exaggerated by his increasing infirmities, and, perhaps, by that restlessness of mind, which, in the midst of bodily complaints, is still hoping to derive some benefit from a change of place. He determined, therefore, to return once more to London, where he arrived in the beginning of September.

Before Sir John Pringle entirely quitted Edinburgh, he requested his friend, Dr. John Hope, to present ten volumes, folio, of Medical and Physical Observations, in manuscript, to the Royal College of Physicians in that city. This benefaction was conferred on two conditions; first, that the Observations should not be published; and secondly, that they should not be lent out of the library on any pretence whatever.

ever. A meeting of the College being summoned upon the occasion, Sir John's donation was accepted with much gratitude; and a resolution passed to comply with the terms on which it was bestowed. He was, at the same time, preparing two other volumes to be given to the University, containing the formulas referred to in his annotations.

Sir John Pringle, upon his arrival at the Metropolis, found his spirits somewhat revived. He was greatly pleased with revisiting his London friends; and he was received by them with equal cordiality and affection. His Sunday evening conversations were honoured with the attendance of many respectable men; and, on the other nights of the week, he had the pleasure of spending a couple of hours with such friends as Lord Charles Cavendish, Mr. Cavendish, the Bishop of Exe-

ter (Dr. Ross), Dr. Heberden, Dr. Watson, Sir George Baker, Dr. Richard Saunders, Peter Holford Esquire, Israel Mauduit Esquire, and occasionally a few gentlemen besides. This was at a Society that had long been established, of which Sir John Pringle had been many years a Member; and which had met, for some time past, at Mr. Watson's, a grocer, in the Strand. Sir John's connection with this Society, and his constant attendance upon it, formed, to the last, one of his principal entertainments. The morning was chiefly employed by him in receiving and returning the visits of his various acquaintance; and he had frequently a small and select party to dine with him, at his apartments in King's Street, St. James's Square. All this while, his strength declined with a rapidity which did not permit his friends to hope that his life would long be continued. On Monday evening, the
fourteenth

fourteenth of January, 1782, being with the society at Watson's, he was seized with a fit, from which he never recovered. He was accompanied home by Dr. Saunders, for whom he had the highest regard, and in whom he had, in every respect, justly placed the most unreserved confidence. The Doctor afterwards attended him with unwearied assiduity, but, to any medical purpose, entirely in vain; for he departed this life on the Friday following, being the eighteenth day of the month, in the seventy-fifth year of his age; and the account of his death was every where received, in a manner which shewed the high sense that was entertained of his merit. On the seventh of February, he was interred in St. James's church, with great funeral solemnity, and with a very honourable attendance of eminent and respectable friends. As a testimony of regard to his memory, at the first meeting of the College of Physicians at

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Edinburgh

Edinburgh after his decease, all the Members appeared in deep mourning.

Sir John Pringle, by long practice, had acquired a handsome fortune; which he disposed of with great prudence and propriety. The bulk of it, as might naturally and reasonably be expected, he bequeathed to his worthy nephew and heir, Sir James Pringle, of Stichel, Bart. whom he appointed his sole executor. But the whole was not immediately to come to Sir James; for a sum equal, I believe, to seven hundred pounds a-year, was appropriated to annuities, revertible to that gentleman, at the decease of the annuitants. By this means, Sir John exhibited an important proof of his regard and affection for several of his valuable relations. He provided, likewise, for two servants, who had lived with him a considerable time; and he left legacies to some particular friends, among whom

whom the Writer of this Life had the honour of receiving a testimony of his remembrance and esteem.

Sir John Pringle's eminent character as a practical physician, as well as a medical author, is so well known, and so universally acknowledged, that an enlargement upon it cannot be necessary. He was distinguished, in this respect, by his attention and sagacity. For the recovery of his patients he was anxiously concerned; and his anxiety might, perhaps, be increased from his conviction, that the art of Physic, though eminently useful, must ever, from unavoidable causes, be attended with a certain degree of uncertainty. His care was rewarded with much success in the course of his practice. In the exercise of his profession, he was not rapacious; being ready, on various occasions, to give his advice without pecuniary views. This he

never denied to the poor ; and, from many of his friends in better circumstances, and who were well able to afford the customary gratifications, he refused to accept of fees.

The turn of Sir John Pringle's mind led him chiefly to the love of science, which he built on the firm basis of fact. With regard to philosophy in general, he was as averse to theory, unsupported by experiments, as he was with respect to medicine in particular. Lord Bacon was his favourite author ; and to the method of investigation, recommended by that great man, he steadily adhered. Such being his intellectual character, it will not be thought surprising, that he had a dislike to Plato. The speculations of that sublime and ingenious, that elegant and beautiful, but at the same time fanciful writer, were by no means suited to the sober spirit of enquiry cultivated by Sir

John Pringle. Indeed, whatever attention he might have paid, in his earlier days, and when he was Professor of Ethics at Edinburgh, to metaphysical disquisitions, he lost all regard for them in the latter part of his life; and, though some of his most valued friends had engaged in discussions of this kind, with very different views of things*, he did not choose to revert to the studies of his youth, but contented himself with the opinions he had then formed.

I shall not conceal from my readers, that Sir John Pringle had not much fondness for poetry †. He had not even any distinguished

* Dr. Price, Dr. Priestley, and Lord Monboddo.

† That he was, however, himself the subject of poetical commendation, will appear from the following short Latin Ode, which was addressed to him, in 1753, by Dr. Theobald:

guished relish for the immortal Shakspeare :
at least, he had too high a sensibility of the
defects of that illustrious Bard, to give him
the proper degree of estimation. The
Writer of this account, who is one of the
warmest admirers of our great Dramatist
and Master of human nature, cannot men-

‘ Ode, Viro ingenio pariter ac docto, JOHANNI
‘ PRINGLE, M. D. et S. R. S. facra.

‘ DIVA Romana cata temperare

‘ Barbiton Cantu, O habilis modorum

‘ Artifex, festis mihi nuper horis

‘ Sæpe vocata !

‘ Fida PRINGELLI modulos corusco

‘ Ede sacratos merito, colendi

‘ Semper et culti, celebri revincti

‘ Tempore ferto.

‘ Inclytis nulli viget is secundus

‘ Laudibus, tu sive animum benignum

‘ Respicias, seu quo Medicum refulget

‘ Clarus honorem.

‘ Concini dignus meliore plectro,

‘ Fac, ut haud surda hoc bibat aure carmen,

‘ Conditum parva licet arte, grato at

‘ Pectore textum.’

(Nichols’s Anecdotes of Bowyer, p. 601.)

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tion it in commendation of his Friend, that he was defective in poetical taste; but he thinks it proper to be recorded, from a regard to truth, and to state a fact which indicates the diversity there is in the understandings, pursuits, and feelings of the ablest men. The mind of Sir John Pringle was too closely occupied by philosophical enquiries, to have much leisure or inclination for attending to the operations of the imagination. Whether this be considered as a defect in him or not, it was certainly a loss in point of real pleasure. A relish for poetry, and for those other compositions by which the fancy is amused, affords a delightful relaxation, after more severe investigations. It tends to produce a cheerfulness and hilarity of spirits, which may possibly not a little contribute to health, as well as to entertainment. Studies of this nature, not only *adolescētiā alunt*, but

seu etatem oblectant. Nay, old age may derive a particular advantage from them, as they are calculated, by furnishing agreeable and lively pictures to the imagination, to soothe the infirmities, and lighten the burdens, of that period.

Sir John Pringle had not, in his youth, been neglectful of philological enquiries; and, after having omitted them for a time, he returned to them again; so far, at least, as to endeavour to obtain a more exact knowledge of the Greek tongue, probably with a view to a better understanding of the New Testament. He paid a great attention to the French language; and it is said, that he was fond of Voltaire's critical writings. How far this might contribute to the honour of Sir John's taste, I shall not decide. However just that eminent Frenchman's observations may have been on some subjects of criticism, the truly ingenious

ingenious and excellent Mrs. Montagu hath amply shewn, that he was absolutely unequal to the task of determining concerning the merit of Shakspeare. Among all his other pursuits, Sir John Pringle never forgot the study of the English language. This he regarded as a matter of so much consequence, that he took uncommon pains with respect to the style of his compositions; and it cannot be denied, that he excels in perspicuity, correctness, and propriety of expression.

Though our Author was not fond of Poetry, there was a sister art for which he had a great affection, and that was Music. Of this art he was not merely an admirer, but became so far a practitioner in it, as to be a performer on the violincello, at a weekly concert, given by a society of gentlemen at Edinburgh. Music, if not too eagerly pursued, or permitted to engross an
undue

undue proportion of time, is a fine relief to the mind of a literary man. It is often neglected, as persons advance in years; and this, I believe, was the case with my Friend.

Besides a close application to medical and philosophical science, Sir John Pringle, during the latter part of his life, devoted much time to the study of divinity. This was with him a very favourite and interesting object. He read many commentators on Scripture, and especially on the New Testament, of which he was anxious to obtain an exact and critical knowledge. In this pursuit, the learned and judicious Bishop Pearce's Commentary and Notes gave him particular pleasure, and were greatly suited to his taste. He corresponded frequently with Michaelis on theological subjects; and that celebrated Professor addressed to him some letters on Daniel's Prophecy

Prophecy of the Seventy Weeks, which Sir John thought worthy of being published in this country. Accordingly, he was at considerable pains, and some expence, in the publication, which appeared, in 1773, under the following title: ‘ Joannis Davidis Michaelis, Prof. Ordin. Philos. et Soc. Reg. Scient. Goettingensis Collegæ, Epistolæ, de LXX Hebdomadibus Danielis, ad D. Joannem Pringle, Baronettum: primo privatim missæ, nunc vero utriusque consensu publicè editæ.’ 8vo*.

Sir John Pringle was likewise a diligent and frequent reader of sermons; which form a valuable part of English literature. Indeed, taken in their full extent, they constitute a much more valuable part of English literature, than, perhaps, is commonly imagined. For, independently of

* Nichols’s Biographical and Literary Anecdotes of William Bowyer, p. 446, 447. Ibid. p. 601.

their

their theological merit, in explaining the doctrines of Natural and Revealed Religion, and throwing light on passages of Scripture, we shall scarcely any where meet with a richer treasure of practical observation, or with reflections on life and manners, that are better calculated to improve the understanding, mend the heart, and regulate the conduct.

If, from the intellectual, we pass on to the moral character of Sir John Pringle, we shall find that the ruling feature of it was integrity. By this principle he was uniformly actuated in the whole of his behaviour. All his acquaintance will with one voice agree, that there never was an honest man. He was equally distinguished by his sobriety. He told Mr. James Boswell, that he had never in his life been intoxicated with liquor; which must be allowed to have been a very laudable

ble proof of the circumspection maintained by him, in the variety of company that he had kept, both at home and abroad.

In his friendships, Sir John Pringle was ardent and steady. The intimacies which were formed by him, in the early part of his life, at Edinburgh, continued unbroken to the decease of the gentlemen with whom they were made; and were kept up by a regular correspondence, and by all the good offices that lay in his power. One of his oldest and most particular friends, was Mr. Alexander Boswell, afterwards Senator of the College of Justice, by the title of Lord Auchinleck. Some unhappy differences having taken place between Lord Auchinleck, and his son Mr. James Boswell, the ingenious, worthy, and well-known author of the Account of Corsica, Sir John Pringle was the benevolent and successful mediator in procuring a reconciliation. In
allusion

allusion to this circumstance, he expressed himself, in a letter to Mr. James Boswell, written in 1773, in the following terms:

‘ I shall be glad to serve you. But remember, in all cases of opposition, I shall be on the ministerial side; I mean, on that of your father, my oldest and best friend. You may inherit after him (if I should survive him) my first affections; but they cannot be alienated during his life.’

With relation to Sir John Pringle’s external manner of deportment, he paid a very respectful attention to those who were honoured with his friendship and esteem, and to such strangers as came to him well recommended. Foreigners, in particular, had great reason to be satisfied with the uncommon pains which he took to shew them every mark of civility and regard. He had, however, at times, somewhat of a dryness and reserve in his behaviour, which

had the appearance of coldness ; and this was the case, when he was not perfectly pleased with the persons who were introduced to him, or who happened to be in his company. His sense of integrity and dignity would not permit him to adopt that false and superficial politeness, which treats all men alike, though ever so different in point of real estimation and merit, with the same shew of cordiality and kindness. He was above assuming the professions, without the reality of respect.

Dr. Johnson hath thought it proper to be recorded of Pope, that, when he wanted to sleep, he ‘ noddled in company ;’ and that he once slumbered at his own table, while the Prince of Wales was talking of poetry. Sir John Pringle had this infirmity, especially in the latter part of his life. It chiefly appeared in the evening, and admits of a very easy and justifiable solution.

He

He had for many years been so remarkably troubled for want of rest, that there was scarcely a single night, in which he did not lie awake for several hours. He had this nocturnal wakefulness to a degree that rendered it a great affliction; and, therefore, it is not surprising, that he should occasionally be overcome by drowsiness. Neither can it be thought strange, that the same cause should have some effect upon his spirits. It was the principal, perhaps the sole reason, of a certain wearisomeness and restlessness that hung about him, and which he sought to remove by changes of situation.

On the religious character of Sir John Pringle it will be necessary more particularly to enlarge; because, such is the temper of the present age, that what is the greatest glory of any man, is often imputed to him as a weakness. The principles

ples of piety and virtue, which were early instilled into our Author by a strict education, do not appear ever to have lost their influence upon the general conduct of his life. Nevertheless, when he travelled abroad in the world, his belief of the Christian Revelation was so far unsettled, that he became a sceptic with regard to it, if not a professed Deist. One cause of this, was the wrong notions he had formed concerning the genuine doctrines of the New Testament; and it will easily be supposed, that he was encouraged in his scruples by the company he met with both in England and in foreign parts. But it was not in the disposition of Sir John Pringle, to rest satisfied in his doubts and difficulties, with respect to a matter of such high importance. He was too great a lover of truth, not to make Religion the object of his serious enquiry. As he scorned to be an implicit believer, he was equally averse to

the being an implicit unbeliever ; which is the case of large numbers, who reject Christianity with as little knowledge, and as little examination, as the most determined bigots embrace the absurdest system that ever was invented. The result of his investigation was, a full conviction of the divine original and authority of the Gospel. The evidence of Revelation appeared to him to be solid and invincible ; and the nature of it to be such, as demanded his warmest acceptance. What contributed entirely to remove the objections which had formerly lain upon his mind, was, his being perfectly satisfied, that our holy religion did not contain some doctrines which have commonly been thought to belong to it. There were three points that, in this view, appeared to him of great importance ; and the removal of his difficulties, with regard to them, effaced every impression he might have received to the disadvantage of Christianity.

ianity. He became fully convinced, by his study of the Scriptures, that the Athanasian doctrine of the Trinity made no part of them ; but that they uniformly concurred in asserting the unity and supremacy of the God and Father of Mankind. He was equally convinced, that they did not confine the mercy of the Supreme Being to a few, exclusively of others ; and that they did not hold out any thing, with respect to the extent and duration of the future punishment of the wicked, which could in the least be considered as an impeachment of the divine justice, rectitude, and goodness. In these sentiments, he agreed with some of the wisest and best men the world hath ever produced, some who have reflected the greatest honour on human nature. He was another instance of those illustrious philosophers, who have not been ashamed of religion ; and added another name to the catalogue of the excellent and

judicious persons, who have gloried in being RATIONAL CHRISTIANS*.

As

* A late writer, whose chief praise arises from the elegance and vivacity of his composition, hath treated the rational Christians with great contempt and severity, and, I may add, with the highest degree of injustice. (Disquisitions on several Subjects, p. 101—118.) He charges them with pretending to be Christians, without believing; a charge which I have no hesitation in asserting to be absolutely contrary to truth. To accuse them, as he does, of want of sincerity, and to put them on a level with the Deists, can only proceed from the grossest ignorance, or from worse motives; which I would not willingly impute to any gentleman of character. There are none who are more firmly persuaded of the truth of the gospel, none who are more clearly convinced of its divine original, none who are more entirely satisfied with the weight and variety of its evidence, none who more sincerely rejoice in its invaluable contents, than rational Christians. To men of this character the world is indebted for the fullest and ablest vindications of the Old and New Testament, against the attacks of Infidelity. From the men of this character have proceeded those works in support of Natural and Revealed Religion, which will stand the test of ages, and against which the efforts of Scepticism will be directed in vain. Locke and Clarke, Hoadly and Sykes, Butler and Jortin, Chandler and Foster, Leland and

As Sir John Pringle was thus firmly persuaded of the truth of the Gospel, he lived
under

Lardner, Abernethy and Duchal, together with various other names that might be mentioned, were all of them rational Christians. I presume that few of the able defenders of Revelation, which this country has produced, would have chosen to be called *irrational* Christians. It is unfortunate for such an irrational Christian as the Author of the Disquisitions, that his mode of writing hath occasioned many persons, who are strangers to his character, to imagine that he is an infidel in disguise, and that his design is to expose our holy religion to contempt. For my own part, I have no doubt of the sincerity of his belief, and of the good intentions of his publications; but I think, at the same time, that the manner in which these intentions have been displayed, is remarkably injudicious. With regard to rational Christians, if there be some doctrines, that have commonly been received, to which they do not give their assent, this doth not arise from the pride of human reason, but from their firm persuasion, that such doctrines are not to be found in the Scriptures. The Writer of the present Note can sincerely assert, that this is his own case. Being entirely convinced of the truth of Revelation, after a full, and, he trusts, a fair investigation of the matter, the sole object of his enquiry is, What does the Bible contain? what are the real dictates and declarations of our Lord and his apostles? Those

under its influence. He was animated with a strong sense of piety to the Supreme Being,

rational Christians, who are supposed to depart the most from the standards of faith generally established, uniformly agree in maintaining a high sense of the invaluable blessings derived from the Gospel. They are satisfied that these blessings were bestowed in a supernatural manner, by the God and Father of Mercies; that Jesus Christ is the dispenser of them; and that they consist of knowledge, pardon, purity, and everlasting happiness. They believe that eternal life is not only revealed by our Saviour, but absolutely ascertained by his death and resurrection. This is a point, the importance of which no words can express. With what justice, then, can any one degrade into the rank of Deists, the men who are fully persuaded, that ‘ the gift of God is eternal life, through Jesus Christ our Lord?’ Every man, who knows the world, must be sensible, that the far greater part of those who discard Revealed Religion, have little or no expectation of a future state. But there is not a single person, among such as are called Rational Christians, who will not say, with the warmest gratitude, ‘ This is the record, that God hath given to us eternal life, and this life is in his Son.’

It is an observation of great moment, and which, therefore, deserves to be attended to, that the believers in Christianity do not differ so much in their sentiments

Being, which displayed itself in a regular attendance upon public worship, in the

ments concerning the nature and value of the blessings derived from the Gospel, as with respect to some other questions. They are all agreed, that, when mankind were ignorant and guilty, corrupt, and liable to a sentence of eternal death, the Saviour appeared, to communicate spiritual instruction, to bestow upon them the forgiveness of sin, to purify their hearts and regulate their conduct, and to raise them up to everlasting felicity and glory. Of the unspeakable excellence, and immense greatness, of these benefits, Christians are alike sensible, and alike ascribe them to the Revelation of Jesus, however they may vary in their opinions concerning the causes, or the effects of the causes, which brought men into their wretched condition; and whatever ideas they may have formed concerning the dignity of the Person by whom the blessings of the Gospel are conveyed, and the peculiar operation of his sufferings. Were it, therefore, ever so certain, that the rational Christians are mistaken in their sentiments, the charge brought against them by the Writer of the Disquisitions, would still be equally uncandid and ill-founded. He is not the only Author who has preferred against them the same accusation. Others have represented them as being no better than Deists: but such manifest ignorance, bigotry, and injustice, ought long ago to have been banished from this kingdom.

exercise of private devotion, and in an endeavour to discharge all the obligations of virtue. Such being the tenour of his life and conduct, and deriving great consolation from Christianity, as an institution of mercy, he rejoiced in a sense of the Divine favour, and in the hope of future happiness. Nevertheless, whether from a constitutional timidity of temper, or from early impressions, or from the state of his body, the approaches of death were met by him with some degree of apprehension. This was not an apprehension with regard to its consequences, but a certain kind of awfulness with relation to the thing itself; a disposition which has been experienced by many worthy persons. The wakefulness before mentioned, with which our Author was afflicted for so many years, will, perhaps, satisfactorily account for this failure of spirits; and to the same cause it may be ascribed, if, in any other respect, he did
not

not sustain the infirmities of age with that full fortitude and dignity of mind, which, though always desirable, cannot, even by the best characters, always be attained.

Sir John Pringle's literary and other connections were so very numerous, that only a small part of them can here be specified. Several of his learned and philosophical acquaintance have already been occasionally mentioned; and if, in adding a few more names to the list, I should be guilty of any improper omissions, it will, I hope, be imputed to what alone it is owing, either to a want of information or recollection, or to the difficulty of choice, amidst such a variety of objects. In early life, our Author entered into a close friendship with the most distinguished persons of the city of Edinburgh; and with some
of

of them he maintained a regular correspondence*. The eminent philosopher, Maclaurin, was his intimate friend; of whose memory he expresses himself, in one of his Discourses, with peculiar affection, and whom he always spoke of, in conversation, with the highest marks of esteem and regard. When he returned to Edinburgh, with the purpose of ending his days in that city, there were still living, of his old acquaintance, Dr. George Wishart, Sir Alexander Dick, Dr. Hope, Dr. Steddman,

* Sir Alexander Dick has preserved a series of letters from Sir John Pringle, being forty-seven in number. They display the excellence of his character in a full light, and shew the warmth and steadiness of his friendship. They contain, likewise, many valuable articles in Medicine and Natural Philosophy, accurately and pleasingly expressed. His letters to Lord Auchinleck (whom he calls his first and best of friends), to Mr. James Boswell, to Dr. Steddman, and other gentlemen, exhibit him in the same advantageous point of view.

and,

and, perhaps, some others, of whom I have not been particularly informed. The loss he had sustained, in the decease of several of his former companions, was in part made up by their sons; among whom Mr. Boswell, Mr. Wallace, Mr. Murray (then Solicitor General for Scotland, and now one of the Lords of Session), and Mr. Maclaurin, distinguished themselves in displaying every proof of attachment and respect to the man, who had been the intimate friend of each of their fathers.

Of Sir John Pringle's acquaintance in England, it would not be easy to give a detail. Were I to attempt such a detail, it would include a large number of the most worthy and eminent characters, of all professions. His conversation was not confined to medical gentlemen, though his

intercourse with them was very great, but extended to many persons of rank and consequence, as well as merit. He liked much to converse with the liberal-minded clergy, whether of the establishment, or among the Dissenters; and he was honoured with the friendship and esteem of some of the most excellent and learned prelates of the church. Among the distinguished philosophers of the age, there were few with whom he was not closely connected; and he had a particular intimacy with Dr. Franklin, till it was interrupted by the unfortunate public contests, which carried that celebrated man to another country, and another scene of action.

Without pretending distinctly to specify Sir John Pringle's more private friends, who were numerous and highly respectable, I must be permitted to mention Edward

Mason

Mason Esq. (formerly Secretary to his Royal Highness William Duke of Cumberland), with whom our Author formed an acquaintance in Germany ; which continued, with unbroken esteem and affection, to the end of life. To this gentleman he bequeathed a testimony of remembrance in his last will. For several years before his decease, there was no one in whom he placed so unreserved a confidence, and for whom he had stronger regard, than Dr. Richard Saunders. His sense of the Doctor's zealous attention and friendship was particularly expressed, by leaving to him his prints and drawings.

It would be impossible for me to do full justice to Sir John Pringle's connections with foreigners. There were no persons who visited England, if they had any taste for philosophical science, that were not recommended

commended to him, and did not cultivate his acquaintance. Besides this, he corresponded with many eminent philosophers and physicians, whom he had never seen. Whether he ever had an opportunity of being personally acquainted with Linnæus, Baron Van Haller, and Tissot, I do not recollect; but he maintained an epistolary intercourse with them, and with almost every distinguished name in Europe, and especially in Germany, France, and Holland. How far, and to whom, his correspondence extended, might have been more exactly specified, if he had not burnt all his letters before his decease. The celebrated Abbé Fontana, during the time of his being in England, was much in the company of Sir John Pringle: but there was no foreigner who, at the different periods of his residence in this country, enjoyed so great an intimacy with him as Dr. Ingen-
houfz.

houfz. — This gentleman was recommended by Sir John to the Emprefs Queen of Hungary, and to the Emperor of Germany, as a proper person to inoculate the Imperial and Austrian family ; in the fuccefsful performance of which, he attained to diftinguifhed emoluments and honours. The high fenfe which he had of his obligations to our Author, in this and in other refpects, he has expreffed in a very handsome dedication, prefixed to his curious ‘ Experiments upon Vegetables.’ This was not the only book dedicated to Sir John Pringle. We have already feen, that Michaelis paid him a fimilar testimony of regard ; and the fame was done by Baron Van Haller, in one of his publications. The reputation in which our Author was held abroad, was uncommonly great ; and was productive of every mark of attention and efteem.

Such

Such having been the character and eminence of Sir John Pringle, it was highly proper that his name should be recorded among the Worthies of Westminster Abbey. Accordingly, under the direction, and at the expence, of his Nephew and Heir, a monument is preparing, of which Mr. Nollekens is the sculptor, and for which an English inscription is intended.

If it had been determined to have had a Latin inscription, there was one, written by a gentleman of the first classical knowledge and taste, which would undoubtedly have had the preference. I have obtained leave to insert it; and it gives me pleasure that I can conclude my account of Sir John Pringle with so elegant and honourable a testimony to his memory.

M. S.

M. S.

Viri egregii JOHANNIS PRINGLE Baronetti,

Quem exercitus Britannicus,

Celsissima Walliæ Princeps,

Regina serenissima,

Ipsius denique Regis Majestas,

Medicum sibi comprobavit

Experientissimum, sagacem, strenuum:

Quem, studiis academicis florentem,

Edinburgenses olim sui

In cathedrâ disciplinæ ethicæ dicatâ

Adhuc juvenem collocârunt:

Quem postea, ætate ac scientiâ proVectum,

Primum perhonorifico ornavit præmio,

Deindè ad summam apud se dignitatem evexit

Societas Regia Londinensis.

Qualis fuerit medendi artifex,

Quali rerum comprehensione præditus,

Materiem suam multiplicem

Quam scienter explicuerit et illustraverit,

Scripta Viri doctissimi testentur

Per Europam omnem disseminata,

Nec foris minùs quam domi nota.

Quâ autem fide et integritate fuerit,

Quam veri tenax et inimicus fraudi,

Quam constans Supremi Numinis cultor,

Ii, quibuscum vixit,

Testes sunt.

Excessit e vitâ, &c.

DISCOVERIES

ROYAL SOCIETY

THE ROYAL SOCIETY MEDAL

S I X
D I S C O U R S E S,

DELIVERED BY

SIR JOHN PRINGLE, BART.

BEFORE THE

R O Y A L S O C I E T Y;

On occasion of Six Annual Assignments of

SIR GODFREY COPLEY's MEDAL:

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A
D I S C O U R S E
O N T H E
D I F F E R E N T K I N D S O F A I R,

DELIVERED AT THE
Anniversary Meeting of the ROYAL SOCIETY,
November 30, 1773.

By Sir JOHN PRINGLE, Bart. PRESIDENT.

PUBLISHED AT THEIR REQUEST.



A

DISCOURSE

ON THE

DIFFERENT KINDS OF AIR.

GENTLEMEN,

IT is with great satisfaction I enter upon this part of my office—to confer, in your name, the prize-medal of the present year upon a Member of this Society so worthy of that distinction.

THE object which Sir GODFREY COPLEY, founder of the benefaction, had in

view, and the manner in which the original pecuniary reward was converted into this more liberal form, having been so lately explained by my honoured predecessor; I need only observe, that though your President and Council have been entrusted with the sole power of adjudging this premium, yet they have now, as, I am persuaded, they have had on former occasions, the greatest solicitude to nominate that person, who, in their opinion, would have obtained all your suffrages.

IN confidence of such unanimity, it is with singular pleasure I acquaint you, that the Reverend JOSEPH PRIESTLEY, Doctor of Laws, has been found at this time the best entitled to so public a mark of your approbation, on account of the many curious and useful experiments contained in his *Observations on different Kinds of Air*, read at the Society in March 1772, and

inserted in the last complete volume of your Transactions*. And indeed, GENTLEMEN, when you reflect on the zeal which our worthy brother has shewn to serve the Public, and to do credit to your Institution, by his numerous, learned, and valuable communications, you will, I imagine, be inclined to think, that we have been rather slow than precipitate in acknowledging so much merit.

YOUR time will not allow me to touch on the subjects of his former Papers †: nay, I apprehend I shall even trespass upon it, by recalling to your memory only a few of those interesting discoveries which Doctor PRIESTLEY has made in these *Observations*: since, in doing justice to others as well as to him, it will be proper to remind you of the progress that had already been made in

* Vol. lxii.

† In Phil. Transf. vol. lviii, lix, lx.

this part of science by men of the greatest abilities in their time, and by other ingenious persons still among us.

THERE is not perhaps any branch of Natural philosophy that has more engaged the attention of the learned, or been more successfully cultivated, than the nature of the common air. The knowledge how indispensable it is to the preservation of animals, must have been coëval with mankind : it was from the beginning, as now, *the breath of life*. It was found likewise to be a necessary support of fire, and they saw that the vegetable creation, deprived of it, languished and died. Nor did the ancient physicians fail to distinguish, at least attempt to distinguish, between the effects of an air too hot and one too cold, an air too moist and one too dry, and between an insalutary and a wholesome air.—Thus far the experience, or the theory of all ages.—

But the less obvious properties of this element, its gravitation and its elasticity, with their long train of consequences, remained unknown, till, about the beginning of the last century, Lord BACON and GALILEO, in that dawn of philosophy which they themselves diffused, began the inquiry. The former, from experiments, ascertained the elasticity of the air ; and upon that principle constructed his *vitrum calendare*, the first thermometer *. The latter discovered that air had weight ; but though that ornament of Italy was not ignorant of the limited suction of a pump, yet to account for the rise of the water so far in it, he still had recourse to Nature's *abhorrence of a void* †.

TORRICELLI, at last, the disciple of GALILEO, by one happy and decisive ex-

* Bac. Nov. Org. lib. ii. aph. 13.

† Dialog. i.

periment, discovered the pressure of the atmosphere; and PASCAL observed, that this pressure varied according to the heights he carried his barometer *. Soon after followed the air-pump, the invention of the celebrated OTTO DE GUERICK; which, though at first a rude and imperfect instrument, yet, improved by himself †, and more by Mr. BOYLE and Dr. HOOK (two of the illustrious fathers of this society), it soon became, in the hands of Mr. BOYLE, the means of opening the richest mines of natural knowledge. In this research, the History of the Common Air, he seemed so far to carry his inquiries, as to leave little to be done by others who should come after him; those parts excepted, depending on geometry and calculation ‡. How succeſs-

* *Traité sur l'Equilibre des Liq.*

† *Gaspar. Schott. De Arte Mechan. Hydr. Pneumat. Exp. nova Magdeburgh.*

‡ *Boyle, Physico-mechan. Exp. & Mem. for a Gen. Hist. of the Air.*

fully

fully these were executed by Dr. HALLEY and Sir ISAAC NEWTON, I scarcely need to mention ; nor the solid foundation on which those great men established the rarefaction of the air ; and in what proportion, according to its distance from the earth *. But it was Sir ISAAC NEWTON alone, who, upon the principle of the air's being compressed by the power of gravity, and that of its elasticity, taught that tremulous bodies would communicate their motion to the air, and thereby excite vibrations in it, spreading every where. Thus he discovered the efficient cause of sounds †.

BUT, before this period, Mr. BOYLE observing, as he himself informs us, how much air was concerned in many of the *phænomena* of Nature, and how necessary

* Phil. Transf. No. 181. p. 104. Abrid. vol. ii. p. 14. Phil. Nat. Princ. Math. lib. ii. prop. 22, 23.

† Phil. Nat. Princ. Mat. lib. ii. prop. 43.

it was to the existence of animals, became solicitous to inquire, whether a fluid of so great importance were not producible by art; if so, he believed that such air might be serviceable in life, particularly in the art of diving, and in *submarine navigation* *. With these views that admirable Naturalist set about making some new experiments, and, from a variety of bodies, by different processes, obtained a pneumatical fluid (from ripe fruit, fermenting and effervescing liquors, and from the putrefaction of animal and vegetable substances) answering, till then, his only criterion of air, in being of a durably elastic nature †. Yet after all, Mr. BOYLE found that these new productions were essentially different from common air, as they presently extinguished flame, and suffocated those animals that

* An attempt of Cornelius Drebell to make a vessel to row under water with men in it. See Boyle's Works, vol. i. p. 69; vol. iii. p. 174.

† Boyle's Works, vol. iv. p. 236, & seq.

attempted

attempted to breathe in them. But though he missed finding what he so much wanted, his labour was not in vain: philosophy was enriched with the knowledge of what he called *factitious* or *artificial* air, which has in the end proved as useful as he could have wished, in explaining several natural appearances, and in being subservient to the wants of man.

BUT this discovery, however interesting to the Naturalist, and to the Chemist in particular*, seems to have been little attended to, till, in the beginning of this century, Sir ISAAC NEWTON observed, that true permanent air arises from fixed bodies by heat and fermentation; and that those aërial particles recede from one another with the greatest force, which upon contact cohered most strongly:—and that dense bodies by fermentation rarefy into

* Hales, Stat. Eff. vol. i. ch. 6. p. 317.

several

several sorts of air ; and that this air, by fermentation, and sometimes without it, returns into dense bodies *. Excited by such authority, the Reverend Dr. HALES (whose amiable as well as philosophic qualities are still fresh on the minds of several gentlemen present), resuming those experiments concerning the separation of air from bodies, confirmed and extended the discoveries of Mr. BOYLE ; shewing not only that air entered into the composition of most bodies, but the very proportion it bore to the rest of the compound, and that often to an amazing quantity †. Dr. HALES likewise examined the mineral waters, those of Pyrmont particularly ; and, finding them abounding with air, to that circumstance he ascribed the spirit and briskness of those fountains. But that excellent author did not seem to apprehend, that in this, as in

* Compare Newton's Optics, Quer. 30, 31.

† Stat. Ess. vol. i. ch. 6.

other instances, the air which he produced was not the common air, but, if I may be allowed the expression, the *factitious* air of Nature; as being of the same kind with what Mr. BOYLE had extracted from fermenting and effervescing liquors; nay, the same with the *mephitic* or deadly vapour of the ancients, or the *mosfeta* of the modern Italians, so frequently met with in the caverns, springs, and lakes of their country: and the same with the *stith* or *choak-damp* in our coal-pits, so often fatal to the miners. It must be owned it was hard to conceive, how these springs should owe their prime virtues to what, in another manner of application, Dr. HALES saw was so destructive of vitality.

Now this notion, concerning the impregnation of the mineral waters by the *mephitic*, was, as far as I know, originally suggested by a foreign Member, Dr. SEIP of Pyrmont,

Pyrmont, first in a treatise he published in the German language, and afterwards in a communication to this Society, in the year 1736, in which he describes a small cavern at Pyrmont, similar to the *grotta de' cani*, near Naples*. But when this ingenious author calls that *mephitis* (which is a durably elastic fluid *sui generis*) a *sulphureous steam*, or a *sulphureo-spirituuous vapour*, he appears to have been imperfectly acquainted with its nature; which is now found to consist of nothing inflammable or sulphureous, and to be of a density, or specific gravity, considerably greater than that of common air.

THE fuller discovery of this principle we owe to Dr. BROWNRIGG of Whitehaven, who, about thirty years ago, began clearly to unfold this mystery. But his curious papers were not then inserted

* Phil. Transf. No. 448. Abridg. vol. viii. p. 659.

in the Transactions, as the too modest Author had requested a delay, till he should be able to make them more worthy of that honour. In his communication he remarks, ‘ That a more intimate acquaintance with those noxious airs in mines, called *damps*, might lead to the discovery of that subtil principle of mineral waters, known by the name of their *spirit*; that the mephitic exhalations, termed the *choak-damp*, he had found to be a fluid permanently elastic; and from various experiments he had reason to conclude, that it entered the composition of the waters of Pyrmont, Spa, and others; imparting to them that pungent taste, from which they were denominated *acidulæ*, and likewise that volatile principle, on which their virtues chiefly depend *.’

IN order to ascertain a fact of so much consequence, Dr. BROWNRIGG took the

* Vid. Phil. Transf. vol. lv. p. 236. & seq.

opportunity,

opportunity, when at Spa several years after, to make some experiments for this purpose ; when he had the satisfaction to find those waters pregnant with the *artificial* or *factitious* air of Mr. BOYLE, the same with that of the suffocating *grotta* near Naples, and the same with the *choak-damp* of our coal-mines ; forasmuch as this air instantly extinguished flame, and the life of those animals he had inclosed in it*. The success of this worthy Member, in thus far analyzing those waters, encouraged others to pursue the inquiry ; and to investigate the manner in which Nature also furnished them with the chalybeate principle †. Mr. LANE therefore, in consequence of a conversation with Dr. WATSON junior (both of this Society), upon an experiment of Mr. CAVENDISH's, by which that gentleman had found the me-

* Vid. Phil. Transf. vol. lv. p. 218. & seq.

† More properly, the *iron-principle*.

phitic air (such as Dr. BROWNRIGG had detected in Spa-water) sufficient to dissolve any calcarious earth*: in consequence, I say, of this conversation, wherein it was surmised, that the same mephitic air might likewise dissolve iron in common water, Mr. LANE made the experiment with air taken from Spa water; and happily succeeded †. By this means the nature of the metallic principle, in mineral waters, was clearly explained; and the whole analysis of those celebrated fountains; so often attempted by chemists and others; and still eluding their laboured researches, was thus, in the most simple manner, brought to light.

Nothing now seemed to be wanting to the triumph of Art, but an easy manner of joining, as there should be occasion, one or

* Phil. Trans. vol. lvii. p. 92. & seq.

† Ib. vol. lix. p. 216. & seq.

both of these principles to common water, in order to improve upon Nature, in the more extensive use of her medicine. This was effected by Dr. PRIESTLEY, after some other important discoveries had been made in this part of Pneumatics, first by Dr. BLACK, Professor of Chemistry at Edinburgh, and then by Mr. CAVENDISH of this Society. The former has shewn that a particular species of factitious air (he calls it *fixed*) adheres to all calcarious earths, magnesia, and alkaline salts, with different degrees of force; and that this fluid can be separated from these substances, and combined again with them, in the same manner as an acid. Upon this discovery he explained in a clear and simple manner many appearances in chemistry, till then deemed the most unaccountable. Such was the effervescence of absorbent earths and alkaline salts with acids, and the change of the mild calcarious earths into quick lime
by

by heat (in consequence of the expulsion of this *fixed* air which neutralizes them) *. I must add, that I have been well informed, that, for several years past, the learned Professor has taught, that the air which unites with alkaline substances is of the same nature with the *mephitic*, or suffocating air of the *grotta de' cani* and mines; the same with what is emitted from vegetables in fermentation; and that in some respects it agrees with the air which has been injured by the breath of animals, or by the burning of fuel: and lastly, that the air or elastic fluid arising from the solution of metals by acids is very different from the former.

MR. CAVENDISH has made several valuable additions to these discoveries, not only with regard to that species of *factitious* air the Professor had denominated *fixed air*,

* Ess. and Observ. Phys. & Liter. vol. ii. p. 157. & seq.

but to other elastic fluids. He has with accuracy ascertained the specific gravity of this fixed air, as expelled from alkaline substances by acids, or from vegetable matter by fermentation; and has demonstrated the similarity of airs produced by either of these two ways. He has confirmed Dr. BLACK's account of the quantity of the fixed air contained in alkaline salts and in alkaline earths. He has shewn that this fluid can be mixed with water, and in what proportion; and that it flies off again from the water, upon heating it, or exposing it to the common air. Lastly, that this species of factitious air imparts to the water the power of dissolving absorbent earths; the experiment, as I observed before, which led to the knowledge, how Nature infused the metallic principle into what are commonly called the *chalybeate waters* *.

* Phil. Transf. vol. lvi. p. 141. & seq.

OF all these facts Dr. PRIESTLEY has carefully availed himself. For having learned from Dr. BLACK that this fixed or mephitic air could in great abundance be procured from chalk, by means of diluted spirit of vitriol *; from Dr. MACBRIDE, that this fluid was of a considerable antiseptic nature †; from Mr. CAVENDISH, that it could, in a large quantity, be absorbed by water ‡; and from Dr. BROWN-RIGG, that it was this very air which gave the briskness and chief virtues to the Spa and Pyrmont waters §: Dr. PRIESTLEY, I say, so well instructed, conceived that common water, impregnated with this fluid alone, might be useful in medicine, particularly for sailors on long voyages, for curing or preventing the sea-scurvy. This,

* Eff. and Observ. Phys. & Liter. loc. cit.

† Experim. Eff. *passim*.

‡ Phil. Transf. vol. lvi. p. 161. & seq.

§ Phil. Transf. vol. lv. p. 218. & seq.

we know, is a putrid distemper, requiring all the antiseptic quality of those mineral waters, without the chalybeate principle, which might injure, by over-heating the blood, too much disposed to inflammation. For this purpose, he made a simple apparatus, for generating this species of air from chalk, and mixing it with water, in such quantities, and in so speedy a manner, that, having exhibited the experiment before this Society, and the College of Physicians, it met with so much approbation, that, in order the Public might the sooner reap the benefit of it, he was induced to detach this part of his labours, and in a separate Paper to present it to the Admiralty*.

THE rest of his observations upon the different kinds of air, addressed to the So-

* A pamphlet intitled, Directions for impregnating Water, &c.

ciety*, contain so much matter, that I will not presume to encroach so far on your time, as to offer even a short abstract of the whole; but shall be satisfied to single out a few of those many discoveries, such as are the most striking, either for their immediate use in life, like that above; or for the explanation of some of the more interesting appearances in Nature.

I COME, therefore, to another species of *factitious* air, called the *inflammable*. Till within these few years, little more was known, than that this kind of subtile fluid was found in mines, in neglected privies, and common sewers; but chiefly in coal-pits, where it is called the *fire-damp*, making sometimes formidable explosions, and indeed often fatal to the miners. I do not recollect that Mr. BOYLE has taken any other notice of it†. But, about forty years

* Phil. Transf. vol. lxii.

† Boyle's Works, vol. iii. p. 101.; vol. v. p. 305, 306.

ago, Sir JAMES LOWTHER, Baronet, favoured the Society with an account, somewhat more particular, of this production of his coal-mines in Cumberland, accompanying it with several bladders filled with that fluid, which, in this house, burnt as readily, as at its source a month before. Yet still this extraordinary substance was considered more as an object of curiosity, than as one of philosophical inquiry, till Mr. CAVENDISH began to make experiments upon it; by which, and the consequences drawn from them, he has added another considerable branch to the doctrine of aërial fluids.

FIRST, he has taught how to produce at will, and in great abundance, this other permanently elastic fluid from three metallic bodies, Zinc, Iron, and Tin, by dissolving them in the diluted vitriolic acid, or spirit of sea-salt. This species of factitious air he has shewn to be surprizingly light,
being

being no more than the tenth part of the weight of common air, and therefore totally different from the *mephitic*, that other species of factitious air we have been treating of, and which, as was observed, is heavier than the air of our atmosphere. Lastly, Mr. CAVENDISH has given several experiments upon the inflammability of various mixtures of this fluid with common air, which are likewise new; and, like the rest, have been made with great precision.

Now, though Dr. PRIESTLEY has also improved upon this enquiry, by the addition of a variety of experiments; in particular, by shewing how this air becomes miscible with water, and deprived of its inflammability; by comparing it with other species of factitious air, in regard to conducting the electrical fluid; by enquiring how far it may be considered as common
air,

air, loaded with the principle of fire, called *phlogiston* by the modern chemists; with other curious observations on this substance: yet all these, with other kinds of factitious air, as I have already too long detained you, I must with regret pass over; one other species excepted, as I reckon it among the most brilliant of Dr. PRIESTLEY's discoveries*.

THIS species he calls the *nitrous air*, without insisting on the propriety of the expression. It was first produced from the Walton pyrites, by means of the spirit of nitre. Dr. HALES, who made the experi-

* I might have added another new species of factitious air, which he terms *acid*, first taken notice of by Mr. CAVENDISH, and more fully investigated by Dr. PRIESTLEY. This is an elastic vapour, expelled by heat from spirit of salt, and not liable afterwards to be condensed by cold. Water readily imbibes this air, and by that means becomes a strong spirit of salt. The same acid air, or vapour, he has also discovered to be a decomposer of substances that contain *phlogiston*, and with them to form a proper inflammable air.

ment,

ment, observed that, when joined to common air, an effervescence ensued, with a turbid red colour of the mixture, and an absorption of part of the common air*. Dr. PRIESTLEY, extending the experiment to other metallic substances, observed, that the same kind of air was by the same acid readily procured from iron, copper, brass, tin, silver, quicksilver, bismuth, and nickel; and that though it constantly, when joined to common air, exhibited those appearances mentioned by Dr. HALES, and more conspicuously in proportion to the purity of the common air mixed with it (that is, its fitness for respiration); yet it made no change with either fixed or inflammable air, or that air tainted by the breath of animals, or the corruption of their bodies. By means of this test, he was enabled to judge of the kind, as well

* Stat. Ess. vol. ii. p. 280.

as of the degree of injury, done to common air, by candles burning in it ; and to perceive a real difference in the air of his study, after a few persons had been with him there. Nay, a phial of air having been sent him from the neighbourhood of a large town, it appeared, upon a comparative trial, to be inferior in quality to that taken up near Leeds, where he then resided. It was upon such a prospect of obtaining a criterion for distinguishing good air from bad, that Lord BACON almost in a rapture breaks out: ‘ These are noble experiments, that can make this discovery ; for they serve for a natural divination of seasons !’ and again, ‘ They teach men to chuse their dwelling for their better health *.’

NOR is this all the use of the nitrous air : Dr. PRIESTLEY shews it to be one of the

* Nat. Hist. Exp. 777.

strongest

strongest antiseptics. The fixed air has been proved by Dr. MACBRIDE, as was remarked, to be powerful in this particular ; but this species of factitious air has been found to be of superior efficacy. And as our Author has discovered it to be miscible with water, he has reason to believe it may be applied to various purposes, such as the preservation of the more delicate birds, fishes, fruits, and anatomical preparations.

I SHALL now conclude with shewing from Dr. PRIESTLEY, what resources Nature has in store against the bad effects of corrupted air, which from various causes infect our atmosphere.

It is well known that flame cannot long subsist without a renewal of common air. The quantity of that fluid, which even a small flame requires, is surprising: an ordinary

nary candle *consumes*, as it is called, about a gallon of air in a minute. Now, considering the vast consumption of this vital fluid by fires of all kinds made by man, and by volcanos, it becomes an interesting enquiry, to ascertain what change is made in the air by flame ; and to discover what provision there is in Nature, to repair the injury done by this means to our atmosphere. Dr. PRIESTLEY, after relating the conjectures of others, and not finding them satisfactory, was fortunate in falling upon a method of restoring air, which had been vitiated by the burning of candles in it. This led the way to the discovery of one of the great restoratives which Nature employs for this purpose, to wit, vegetation. See by what induction he proves his opinion.

It was natural to imagine, that, since the change of common air is necessary to vegetable, as well as to animal life, both
plants.

plants and animals rendered it foul in the same manner, so as to become unfit for farther life and vegetation. But when with that expectation the Doctor had put a sprig of mint, in a growing and vigorous state, under an inverted glass jar standing in water, he was agreeably disappointed to find, that this plant not only continued to live, though in a languishing way, for two months, but that the confined air was so little corrupted by what had issued from the mint, that it would neither extinguish a candle, nor kill a small animal which he conveyed into it. What farther evinced the salutary nature of the *effluvia* of vegetables; he found that air, vitiated by a candle left in it till it burnt out, was perfectly restored to its quality of supporting flame, after another sprig of mint had for some time vegetated in it. And to shew that the aromatic vapour of that plant had no share in restoring this purity to the air,

he

he observed, that vegetables of an offensive smell, and even such as scarcely had any smell at all, but were of a quick growth, proved the very best for this purpose. Nay more, the virtue of growing vegetables was found to be an antidote to the baneful quality of air corrupted by animal respiration and putrefaction.

WE have said, that neither candles will burn, nor animals live, beyond a certain time in a given quantity of air ; yet the cause of either so speedy a death or extinction was unknown ; nor was any method discovered for rendering that empoisoned air fit again for respiration. Some provision however there must be in Nature for this purpose, as well as for that of supporting flame : without such, the whole atmosphere would in time become unfit for animal life, and the race of men, as well as beasts, would die of a pestilential distemper:
Yet

Yet we have reason to believe, that in our day the air is not less proper for breathing in, than it was above two thousand years ago; that is, as far as we go back in Natural History. Now, for this important end, the Doctor has suggested, to the Divine as well as to the Philosopher, two grand resources of Nature: the vegetable creation again is one, and the sea, and other great bodies of water, are the other.

As to the former, having found that plants wonderfully thrive in putrid air, he began to attempt, by means of growing vegetables, to purify air that had been injured by animal respiration and putrefaction; nor was he less successful than before. These plants were sure to recover the air to a degree of fitness for breathing in it, and that in proportion to their vigour, and the care he took to remove the rotten leaves

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and

and branches ; which, remaining, would have marred the operation.

WITH regard to the second resource of Nature, namely the ocean and other waters, Dr. PRIESTLEY having observed, that both the air corrupted by the breath of animals, and that vitiated by other putrid matter, was in a good measure sweetened by the septic part infusing itself into water, he concluded, that the sea, the great lakes and rivers, which cover so large a proportion of the globe, must be highly useful, by absorbing what is putrid, for the farther purification of the atmosphere : thus bestowing what would be noxious to man and other animals, upon the formation of marine and other aquatic plants, or upon other purposes yet unknown.

FROM these discoveries we are assured, that no vegetable grows in vain, but that
from

from the oak of the forest to the grass of the field, every individual plant is serviceable to mankind ; if not always distinguished by some private virtue, yet making a part of the whole which cleanses and purifies our atmosphere. In this the fragrant rose and deadly nightshade co-operate : nor is the herbage, nor the woods that flourish in the most remote and unpeopled regions, unprofitable to us, nor we to them ; considering how constantly the winds convey to them our vitiated air, for our relief, and for their nourishment. And if ever these salutary gales rise to storms and hurricanes, let us still trace and revere the ways of a beneficent Being ; who not fortuitously but with design, not in wrath but in mercy, thus shakes the waters and the air together, to bury in the deep those putrid and pestilential *effluvia*, which the vegetables upon the face of the earth had been insufficient to consume.

THIS, GENTLEMEN, is what I had to say upon the occasion : perhaps too much ; but the fruitfulness of the subject, with my earnest desire of commemorating some of the more important experiments and conclusions of Dr. PRIESTLEY, and of those who preceded him in these enquiries, will, I hope, plead my excuse. Nor can I conclude without congratulating this illustrious Body, on the possession of so many members and friends, so capable to promote the great ends of this institution ; and who have within these few years so eminently distinguished themselves, by the lights they have thrown, not only upon this, but upon other of the more subtile fluids of Nature. You will understand, that to these discoveries upon factitious air, I join those amazing ones upon magnetism and electricity, with all the uses resulting from them. Here you will recollect the prediction of him, who best taught the method of investigating

tigating philosophical truth, the incomparable Lord BACON, who, with that spirit of divination peculiar to exalted genius, assured his disciples, that when men should cease to trifle in framing *hypotheses*, and building hasty systems; and should, by a proper induction from sober and severe experiments, attain to the knowledge of the *forms* of things [their more intimate qualities and laws]; they should in the end command Nature, and perform works as much greater than were supposed practicable by the powers of natural magic, as the real actions of a *Cæsar* surpassed the fictitious ones of the hero of a romance*. Some earnest, nor that inconsiderable, of this magnificent promise this Society has already obtained. Let those who doubt, view that Needle, which, untouched by any loadstone, directs the course of the British ma-

* Compare Bac. De Dignit. et Augment. Scient. lib. iii. cap. 5.

riner round the world ; or that apparatus, so perfectly imitating the long supposed imitable lightning ; or that other, which disarms the clouds of that tremendous meteor : or (not to depart from my subject) let them see how Art can, from chalk only, the least promising substance, generate, or call it unfetter, a copious elastic fluid imprisoned in it, the poison of man, or his medicine, according to the mode of application ; which, though invisible, yet dissolves earth and metals, and imparts the spirit and virtue to the most prized of mineral waters. Yet these are but inventions of yesterday : I would strictly say, inventions within the memory of my youngest hearer. If to these late acquisitions, so honourable to this Society, I add those in Natural History, by the zeal and unwearied attention of some worthy members, who have extended your correspondence, and adorned your Museum ; and by those other

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gentlemen,

gentlemen, who, animated with a noble spirit, have, to their lasting honour, undertaken the most dangerous and most distant voyages in pursuit of Natural Knowledge : I say, when to the progress you are making in Experimental Philosophy, I add that in the History of Nature, every true lover of science will rejoice to think, that your affairs have not, perhaps, at any period, been in a more flourishing condition.

Dr. PRIESTLEY,

IT is now time that, in the name and by the authority of the Royal Society of London, instituted for the improvement of Natural Knowledge, I present you with this Medal, the palm and laurel of this Community ; as a faithful and unfading

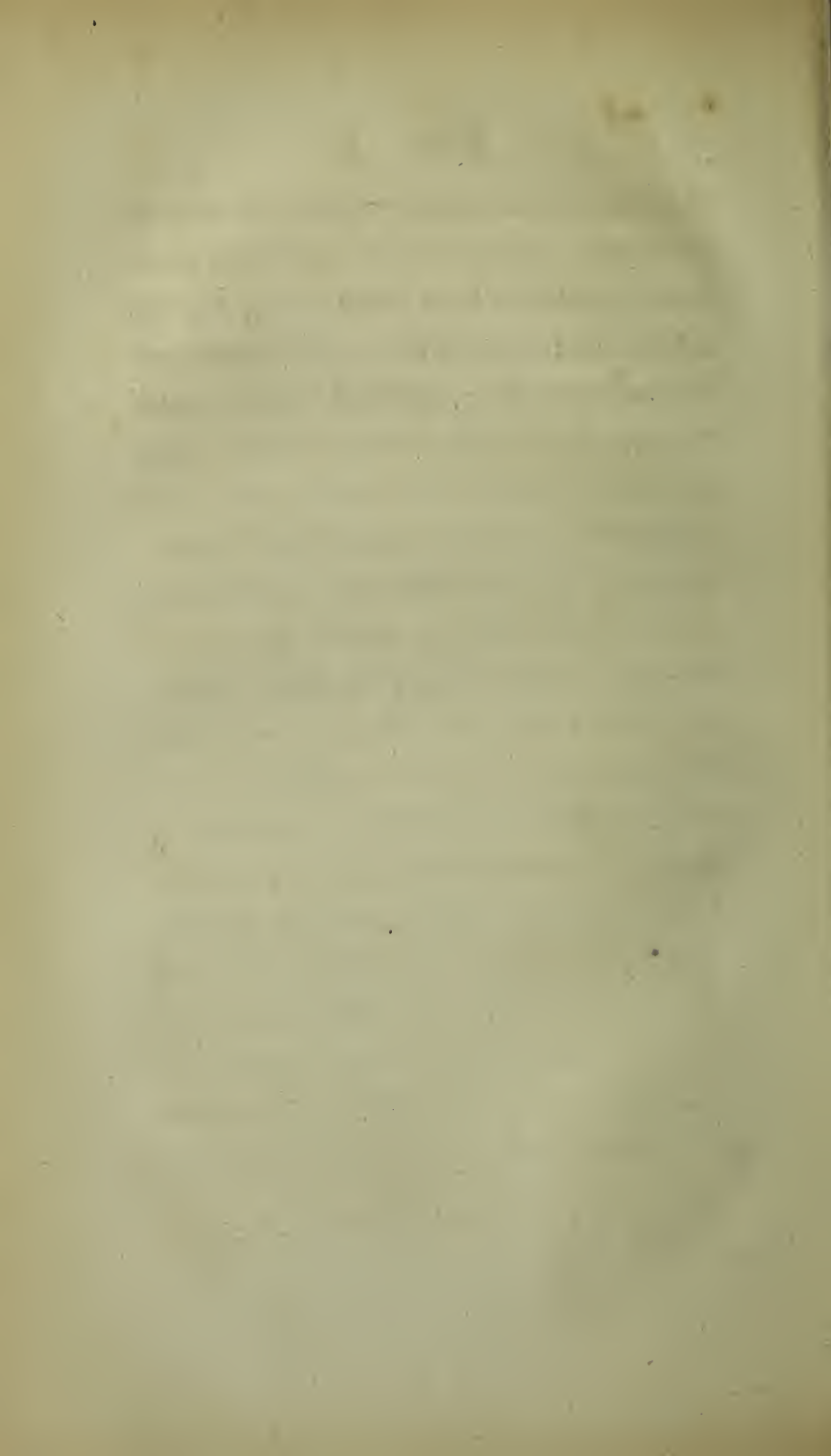
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testimonial

testimonial of their regard, and of the just sense they have of your merit, and of the persevering industry with which you have promoted the views, and thereby the honour, of this Society. And, in their behalf, I must earnestly request you, to continue your liberal and valuable inquiries, whether by farther prosecuting this subject, probably not yet exhausted, or by investigating the nature of some other of the subtile fluids of the universe. You will remember, that *Fire*, the great instrument of the chemists, is but little known, even to themselves; and that it remains a *Query*, what was by the most celebrated of philosophers proposed as such, whether there be not a certain fluid (he calls it *Æther*), the cause of gravity, the cause of the various attractions, and of the animal and vital motions*. These, SIR, are indeed large demands: but the Royal Society have

* Newton's Optics, Quer. 18—24.

hitherto been fortunate in their pneumatic researches. And, were it otherwise, they have much to hope from men of your talents and application, and whose past labours have been crowned with so much success.



A
DISCOURSE
ON THE
TORPEDO;

DELIVERED AT THE
Anniversary Meeting of the ROYAL SOCIETY,
November 30, 1774.

By Sir JOHN PRINGLE, Bart. PRESIDENT.

PUBLISHED BY THEIR ORDER.



A
DISCOURSE
ON THE
TORPEDO.

GENTLEMEN,

THE disposal of the annual Prize-medal, founded on the benefaction of Sir GODFREY COPLEY, Baronet, having for some years past devolved upon your President and Council, they have hitherto been fortunate in executing their trust in such a manner as to receive your approbation.

bation. Indeed, the strict regard for the honour of the Society, and the deference due to the opinions of the other learned Members, have been so much the objects of their attention, that they could not well fail to be directed by them to such of your publications, as were most deserving of your favourable notice; and they flatter themselves, that they shall not now be less successful than on former occasions. For, if you call to mind the various Papers of Experiments in the last volume of your Transactions, you may remember, that though you warmly acknowledged the merit of many of them, yet it was with peculiar pleasure you listened to that from Mr. WALSH, upon the Torpedo, on account of the new and very striking circumstances contained in that communication, and of the pains and time bestowed by that gentleman on this inquiry.

BUT,

BUT, in order to your more freely sealing the choice of your Council with your suffrages, permit me, GENTLEMEN, first to lay before you a short abstract of what had been done in this branch of Natural History, antecedently to Mr. WALSH's experiments; and then to remind you of a few of his principal ones, that while we do justice to our worthy brother, none may be defrauded of the praise due to their labour.

THE Torpedo, or cramp-fish, a species of the ray, being a common inhabitant of the Mediterranean, was early known to the Greeks. We find it first mentioned in a book anciently ascribed to HIPPOCRATES, though only as an esculent fish; but the name alone (*νάρκη*) is sufficient to ascertain the knowledge the ancients then had of its
torporific

torporific qualities. And PLATO, nearly contemporary with HIPPOCRATES, certainly knew of them, as appears by the humorous comparison he makes of SOCRA-
TES to that animal, which he puts into the mouth of MENON, in his dialogue of that name. And his celebrated disciple in physics, ARISTOTLE, particularly treats of it in his History of Animals. The Torpedo (says he) hides itself in the sand or ooze, and, whilst the other fishes swim over it, and touch it, he benumbs them, so as to catch them and feed upon them: as a proof, the mullet, the swiftest of the watery race, is found in his stomach.

BUT though ARISTOTLE knew that the touch of the torpedo stupified other fishes, he seems not to have known that this extraordinary effect could be transmitted to other animals not in immediate contact with it, but by the interposition of a stick,
a rope,

a rope, or water ; facts too curious to have been omitted, had he ever heard of them. Possibly he might have been informed, but rejected the accounts as fabulous (for of all the ancients none appear to have been so much on their guard against imposition) ; or he might have thrown them into some part, that has been since lost, of his book called *Θαυμάσια Ἀκυσινὰ*, *Wonderful Relations*. Yet ARISTOTLE had only the testimony of fishermen for what he reports of the torpedo : indeed he expressly says so. In those days, and for many ages after, the pride of Man set him above experiments ; and above the suspicion, that, by such low and mechanical operations, he was to discover causes, and learn to reason. ARISTOTLE himself, that admirable genius, knew not this. Had the great Stagyrice heard, that, to understand by what principles the torpedo acted, a Naturalist from Britain had travelled through Gaul to the Atlantic

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Ocean,

Ocean, and on that coast had made a hundred experiments upon that fish, and with success; there is no doubt but he would have placed that account among the chief of his *Wonderful Relations*. Lord BACON was the first who detected and combated this presumptuous error, and who, by humbling the vanity of man, exalted his power over the works of Nature. He was the first who taught, that as *our bread*, so our science was to be earned *by the sweat of our brow*; and the works of this Society will, I trust, be an everlasting testimony of the truth of his doctrine.

THEOPHRASTUS, the learned scholar and successor of ARISTOTLE, appears to have been better informed concerning the torpedo than his Master. ATHENÆUS relates, that this philosopher, in his book on venomous animals, observed that the torpedo conveyed this benumbing sensation

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through

through sticks and spears into the hands of the fishermen that held them. And since I have quoted ATHENÆUS, though not in a chronological order, I shall add, that he mentions DIPHILUS of Laodicea, for taking notice, in his commentary upon the *Theriaca* of NICANDER, that it was not the whole, but certain parts of the body of the torpedo, that occasioned the torpor. HERO of Alexandria, in his *Pneumatics*, mentions this fish as emitting effluvia through brass and iron, and other solid bodies.

PLINY, the laborious and useful compiler of ancient natural science, too little a philosopher himself, and too great a lover of the marvellous, has treated this subject accordingly. Thus, he says, the power of the torpedo may be felt through the length of a rod or a spear, which is a fact; but that this fish binds the legs of the nimblest person that treads upon it, is an exaggeration;

tion ; and that this animal is able to bind the arms of the strongest, at a distance, is false.

PLUTARCH, though no professed naturalist, yet furnishes us with a fuller and juster account of the torpedo. According to him, this creature not only benumbs all those that touch it, but also strikes a numbness through the net into the hands of the fishermen : nay, as some report, if it happen to be laid on the ground, alive, those that pour water upon it shall be sensible of some diminution of their feeling. Now whether this last fact has been confirmed by later experiments, I have not learnt ; but I am inclined to believe it, as not inconsistent with Mr. WALSH's principles. PLUTARCH adds, that whilst the torpedo swims around his prey, he emits certain effluvia, like darts*, that first affect the

* Gr. ὥσπερ βέλη διασπείρει ἀπορροάς.

water,

water, and then the fishes in it ; which, being thus disabled from defending themselves, or escaping, are held, as it were, in bonds, or frozen up.

FROM ÆLIAN, who writes a History of Animals, we might expect more information, on this subject, than from any other author ; but we are much disappointed. He has been satisfied with reciting a few of the common reports, and adding others, too absurd to deserve repetition. It is remarkable, that these two professed writers of Natural History, PLINY and ÆLIAN, should of all the ancients give us the lamest and most fabulous accounts of this subject of our inquiry.

PASSING from the philosophers to the physicians, we shall receive little more satisfaction. Before the days of GALEN, the torpedo was applied alive to parts af-

fects, and particularly for the cure of an obstinate head-ach, as appears from SCRIBONIUS LARGUS, who lived under CLAUDIUS, and from DIOSCORIDES, who flourished soon after. But GALEN, always reasoning, and opposing empirical practice, assigns a cause for that salutary effect. His physiological system was in a great measure founded on the four *primary qualities*, cold, hot, wet, and dry. He conceived, therefore, that the torpedo acted by a frigorific principle; for as cold occasions a numbness in an animated body, so does the shock given by that fish. Such were the theory and reasoning of that age; yet, bad as they were, they prevailed in the schools of medicine upwards of a thousand years. GALEN was confirmed in his opinion, by seeing, as he himself testifies, that disorder removed by the touch of a living torpedo; which, being of a cold nature, stupified or blunted the acute sense of pain. The fol-

lowers

lowers of this medical chief improved upon their leader. A living torpedo not being always at hand, when a refrigerating medicine was indicated, the deficiency was supplied by preparing an oil from the dead animal, which they were assured must possess all the virtues of the living one. Upon this conceit, we find PAULUS of Ægina, one of the ancients of the Galenic school, recommending this oil for tempering the hot humour of the gout, and for other ailments that required cooling applications.

Now, considering what little information we have received from the philosophers and physicians among the ancients, it will scarcely be expected, that we should find more among their poets. Poetry, the creature of the imagination, can seldom avail itself of strict history for a subject, whether in the natural or political world. The historians of either can yet see but

parts of a great system, and these, in appearance, often crooked and deformed, from not knowing how they are to tally and to be put together, to compose the fabric of the universe and the history of man. Such disjointed materials make therefore but indifferent themes for a bard, whose aim is to captivate the fancy with something beautiful and finished. In effect, OPPIAN has made no improvement in the history of the torpedo, though he contrived in his *Halieutica* to write an elegant description of it, without departing much from truth. He not only commemorates the more than poetical powers with which Nature has endowed this fish; but distinguishes, like DIPHILUS, the parts where they peculiarly reside. These parts he calls λαγόνες (the flanks), from which, as OPPIAN imagined, the animal had a faculty of darting upon other fishes certain substances, he terms κερκίδες, but whereof the meaning

meaning is obscure. To the former of these expressions CLAUDIAN undoubtedly alludes, in a line of those verses which he copies from OPPIAN, in celebrating the properties of the torpedo :

Sed latus armavit gelido Natura veneno.

BUT, as the Roman Poet has nothing new of his own, I shall with him close the relations I have been able to find of this curious fish in the monuments of antiquity. We must confess them to be all unsatisfactory; and the more, as it does not appear that there has been one, GALEN excepted, of all the above-mentioned ancient sages, who had ever seen a living torpedo, much less who had made experiments on it; and, least of all, who had dissected it. The result of their inquiries served for little more than a winter's tale. Such are the accounts that I have been able to collect from the ancients, concerning this *wonder of the deep*;

omitting only such reports as seemed to be either superstitious or fabulous. But of both sorts, you may be assured, that, in those days of credulity, so many were imposed on the world, that we are not to wonder, if there have been men of genius and learning, who, not taking the pains to make experiments themselves, or strictly to enquire into those made by others, have presumptuously treated the whole affair as a vulgar error.

WITH the fall of the Roman Empire, the history of animals, imperfect as it was, with all other sound learning, sunk into the darkness of the times; nor did it emerge before the sixteenth century, an æra ever memorable for the revival of science. Then lived and flourished BELON, RONDELET, SALVIANI, GESNER, and others, who not only restored what was anciently known in Natural History, but greatly improved the
subject,

subject. Yet experiments were still rare and feeble, till, in the next century, HARVEY appeared, and began to make them on birds and quadrupeds. Nor did that famous interpreter of Nature finish his career, and close his eyes in death, before they beheld the rising state of this Society, and the *Accademia del Cimento*, our elder but short-lived sister, already formed. Some of the most eminent of that academy, judging an enquiry into the truth of what had been recorded concerning the torpedo to be an object worthy their attention, availed themselves of their vicinity to a sea, stored with that sort of fish, to make the trials. REDI, one of the most liberal and enlightened geniuses of that age, began, and was afterwards assisted by BORELLI, and STENO the Dane, his colleagues. Lastly LORENZINI, his scholar, engaged in the same pursuit, and published a curious treatise upon the subject.

REDI'S

REDI's first step was, by experiments, to distinguish between the real properties of the torpedo, and such as had erroneously been ascribed to it, by the learned, as well as by the vulgar of former times. To this research he added the anatomy of the animal ; so that REDI was also the first, who with any accuracy described those crooked substances, lying on each side of the spine, near the head, which he considered as muscles (from thence named *musculi falcati*), that projected certain effluvia, occasioning the sensation of numbness, more or less, as the animal was excited to put these organs into action. This hypothesis, of the transmission of effluvia, was immediately embraced by LORENZINI, and afterwards by CLAUDE PERRAULT. But the former, not understanding how effluvia could pass from the body of one animal into that of another, without immediate contact, contradicted, we may say, the evidence

evidence of his senses, by denying the sensation he must have had upon touching the torpedo with a stick, a spear, or the like instrument; unless we should suppose that those subjects, on which he made his trials, were too weak for exerting the full energy of their species.

FROM the like causes also erred the excellent BORELLI. But his theory not admitting the emission of benumbing particles, affecting the hand, either in immediate contact with the fish, or touching it with a stick, or the like, he referred the sensation to a certain brisk undulation of the parts touched, which the animal could excite at will. This action he compared to that of a stretched cord, put into quick vibrations.

INTO a similar deception, in the next generation, fell that ornament of his country

try

try and of his age, the excellent M. DE REAUMUR, upon refuming this fubject. For, in the year 1714, being on the coaft of Poitou, he took that opportunity of making fome new experiments upon the torpedo, which, with the refult, he communicated to the Royal Academy of Sciences at Paris. His brethren of that illuftrious fociety adopted his hypothefis, as did indeed the Ingenious over all Europe; and fo natural did it appear to them, that every one wondered it had not been fallen upon before. What then was this new fyftem? In effect, one not very different from that of BORELLI; for, inftead of the undefined vibrating parts of the latter, M. DE REAUMUR fubftituted mufcles (the *mufculi falcati* of REDI and LORENZINI), which, by the vivacity of their action, impreffed on the hand, that touched thefe parts, a fenfation of numbnefs, owing to the ftoppage of the progreflion of the
nervous

nervous fluid, or a repulsion of the same. But, to obviate what might be objected, the celebrated investigator was bound to deny that this impression of numbness could be communicated through water, a net, or any other soft and yielding substance; nay, through a stick, except a very short one. In fact, M. DE REAUMUR did deny such transmissions; and yet it is certain, that the shocks from the torpedo are not less conducted through such *media*, than those from a charged electrical phial. Shall we then accuse of want of candour those celebrated authors, BORELLI, LORENZINI, and M. DE REAUMUR? By no means: but let us lament the weakness of the human intellect, which, prepossessed by system, will often not perceive such objects as would strike the senses of any other person, nay most certainly their own, in a more unprejudiced state of mind! And let us regret that other infirmity, so incident

to the best understanding, the too great forwardness to account for every appearance in Nature, from such principles as are known, without considering how many yet remain to be discovered! There was a time, and that within the memory of many of my hearers, when thunder and lightning were thought sufficiently accounted for, from sulphureous and nitrous vapours mixing with the air. At present, we doubt of the existence of such vapours in the atmosphere, and are otherwise sure, that the electrical fluid only is concerned in the formation of that meteor. Now it seems this very fluid is the efficient cause of the amazing qualities of the torpedo. Nothing could be more unexpected, yet perhaps nothing more true.

THE discovery of the Leyden Phial opened a wide and rich field for the advancement of philosophy; and to the honour

nour of this Society it will ever be remembered, how much they have availed themselves of that fortunate accident, for interpreting some of the more intricate phenomena of Nature. A few years after that memorable event, the celebrated professor ALLAMAND, Fellow of this Society, hearing of a fish, in the Dutch settlement of Surinam, resembling a congre-eel, but with properties similar to those of the torpedo, engaged his friend M. 's GRAVESANDE, governor of Essequibo, to make the enquiry. That gentleman readily complied; and, in the year 1754, wrote M. ALLAMAND a letter on the subject, which was soon after published in the second volume of the Transactions of the Society at Haerlem. M. 's GRAVESANDE says, that the experiment was made on a species of eel, the Dutch call *sidder-vis* (*tremble-fish*), and that it produced the same effects with electricity, with which he had been well

F acquainted,

acquainted, by having, with his learned correspondent, made many experiments with the electrical phial; nay, that the shocks from the fish were much more violent, if it happened to be strong and lively of its kind; for then it would infallibly throw the person who touched it to the ground. But M. 's GRAVESANDE adds, that such exertions, in this animal, were accompanied with no sparks of fire, as in an electrical machine. Thus far I have abridged M. 's GRAVESANDE's Letter. M. ALLAMAND subjoins, that he was satisfied that this eel must be a species of the *gymnotus* of ARTEDI; and all our subsequent accounts have confirmed his opinion.

IN the second part of the sixth volume of the same valuable Work, we find, of the same animal, a more ample relation extracted from some Letters of M. VANDER LOTT, dated from Rio Essequibo, 1761.

This

This gentleman makes two species, the black and the reddish, though he acknowledges, that, excepting the difference of colour and degree of strength, they are not materially different. In most of the experiments with these animals, M. VANDER LOTT remarked a wonderful similitude between them and an electrical apparatus: nay, he observed, that the shock could be given to the finger of a person, held at some distance from the bubble of air, formed by this eel, when it rises to the surface of the water in order to breathe; and he concluded, that at such times the electrical matter was discharged from its lungs. He mentions another characterizing circumstance; which is, that though metals, in general, were conductors to its electrical fluid, yet some were found to be sensibly better than others for that purpose.

ABOUT the same time that M. 's GRAVE-SANDE made his discovery in America,

M. ADANSON, an eminent French naturalist, met with the same, or a similar fish, in the river of Senegal in Africa. He takes notice, that this animal had little relation to any of the known inhabitants of the water; that its body was round, and without scales, like an eel, but much thicker in proportion to its length; that it was well known to the natives, and that the French called it *trembleur*, from the effects it produced; not so much a numbness, like that arising from the torpedo, as a very painful trembling in the limbs of those who touched it. He adds, that this effect did not sensibly differ from the shock given by the Leyden Phial, which he had felt; and that it was communicated, in the same manner, by simple contact, or by the interposition of a stick, or an iron rod (five or six feet long), so as to force the person to drop whichever of them he had in his hand.

M. FERMIN,

M. FERMIN, in his Natural History of Surinam, published at Amsterdam in 1765, observes of a fish, which the Dutch there call *Beef-aal* (*tremble-eel*), that one cannot touch it with the hands, or even with a stick, without feeling a horrible numbness in the arms, up to the shoulders. And he farther relates, that, making fourteen persons join each other by the hands, whilst he grasped the hand of the last with one of his, and with the other touched the eel with a stick, the whole number felt so violent a shock, that he could not prevail on them to repeat the experiment. This fish, I believe, we may with probability say, was the same species of *gymnotus* described by M. 's GRAVESANDE and M. VANDER LOTT, though the Author does not compare its operations to those of the electrical phial.

THE earliest account, for a distinct one, that I have met with of this kind of eel, in that quarter of the world, is by M. RICHER, the astronomer, recorded by M. DU HAMEL, in his History of the Royal Academy of Sciences, for the year 1677. In the island of Cayenne, where M. RICHER had made his observations, there is a fish, says M. DU HAMEL, not unlike a congre-eel, which, touched with the finger, or even with the end of a stick, affects the arm with a numbness, nay the head with a giddiness, and the eyes with a dimness of sight, which M. RICHER had himself felt upon making the experiment.

IF any farther evidence were wanting, to ascertain the electrical nature of this eel, in those parts, I would recommend the perusal of the Essay on the Natural History of Guiana, by Dr. BANCROFT, Member
of

of this Society, where the reader will find several curious experiments made on this animal by that gentleman. But, as the book is in every body's hands, I shall only take notice, that the Author confirms M. VANDER LOTT's account, of a shock from this animal being communicated through a considerable space of air ; a circumstance to which we have nothing similar in the torpedo, though it be a common effect in an electrical discharge.

I SHALL not, therefore, GENTLEMEN, take up more of your time, with offering you farther accounts of these curious animals, given us by travellers ; and the less, as I have met with no original ones, excepting the above, but what, from either too much brevity, or manifest signs of inaccuracy, have left much doubt to what *genera* of fishes those electrical ones were to be referred. I should only except that eel,

which M. DE LA CONDAMINE describes in his voyage down the River of Amazons, that was most probably the true electrical gymnotus (so commonly found in the rivers of the adjacent country of Guiana), about which we have been just discoursing. Not so that fish which Mr. MOORE found in an African lake near the Gambia ; nor that other, which Mr. ATKINS saw in the river Sierra-leon, likewise, in Africa. And it is pretty evident that the electrical fish, mentioned and delineated, but scarcely described, by NIEUHOF, as taken in some of the lakes of India, and called by the Dutch *meer-aal* (*lake-cel*), is no species of the gymnotus, at least if justly drawn ; since we find there a long fin on the back of that creature, and none on its belly. No more should that fish, provided with torporific powers, which PISO found in Brazil, have any other relation to the gymnotus, since the Author compares it in figure to a sole : nor that
other,

other, of the same country, possessed of similar qualities, which PISO calls *Piraqué* (MARGRAF, *Puraqué*), if it at all resembled the figures given of it by these travellers and natural historians. I would pass the same judgment upon the Indian *congrus monstrosus* of BONTIUS. And I should hesitate about that eel, the subject of a Paper communicated to this Society in the year 1680, by Dr. GALE, from the author Mr. BATEMAN, who had been twenty years a planter in Surinam. All that I would with any degree of certainty conclude, is, that, among fishes, the electrical properties are not confined to that species of ray called the torpedo, nor to that species of gymnotus called the *gymnotus electricus*; but that Nature has endowed with the same powers several other inhabitants of the waters, though hitherto imperfectly known.

Now,

Now, in justice to those authors who have first mentioned the electric gymnotus, and especially to those who have originally furnished a similitude between the properties of the torpedo and those of that electrical eel, and between the properties of both and those of the Leyden Phial, I have thought proper to commemorate their names on this occasion ; though, after all, I have reason to believe that our worthy Brother has taken the hint of making his experiments from none of them, but solely from what he had read concerning the torpedo in writers, who thought of nothing less than referring such powers in animals to an electrical origin ; nay, who lived, many of them, long before the laws of electricity were known. Nor had the surprisingly benumbing effects of the electric gymnotus ever been so narrowly observed, much less confronted with an electrical apparatus, as that we could with any precision

sion say, how far Nature had carried the analogy between the two.

TO Mr. WALSH, therefore, we owe not only the first, but a numerous set of the best chosen experiments on the torpedo, for ascertaining its electrical nature, together with some correct and elegant drawings of the entire animal, and of some of its principal organs that appeared upon dissection. For this latter part of the disquisition, the Society, as well as Mr. WALSH, is much beholden to another Member, Mr. JOHN HUNTER, who thereby has supplied us with an useful addition to the anatomical examination of the animal by REDI, STENO, and LORENZINI. And I may moreover acquaint you, that, though Mr. WALSH has laid before us an account of his principal experiments, his occupations have not yet permitted him to enumerate every curious particular that occurred to him

him in the course of his research ; as I can testify, from having been favoured with the perusal of the journal he had kept of all his transactions.

THE very first experiment of Mr. WALSH discovered the electrical quality of that fluid in the torpedo (which had so long distinguished this fish), by his conveying it through the same conductors with electricity, such as metals, water, and animal fluids ; and by intercepting it by the same non-conductors, namely, glass and sealing-wax. Nor in this circumstance only did the similitude between the electric and torpedinous fluids appear : one of the most brilliant of Mr. WALSH's discoveries was, that this animal not only could accumulate in one part a large quantity of electric matter, but was furnished with a certain organization disposed in the manner of the Leyden Phial. Thus, while one surface of
the

the electric part (suppose on the back) was charged with this matter, or, as it is called, was in a positive state, the other surface (that on the belly) was deprived of it, or was in a negative state ; so that the equilibrium could be restored, by making a communication between the two surfaces, by water, the fluids of the human body, or metals. A man, pressing upon one of these surfaces with one hand, could, with the other, by the mediation of his own fluids, make a circuit for the conveyance, and at the same instant receive a shock ; viz. the same sensation that is impressed by the electric matter in passing through our arms and body, from the inside of a charged Leyden Phial to its outward coating. We need but attend to the following experiment, which Mr. WALSH made at Rochelle, in presence of the Academy there, to see how admirable this circuit is, and how similar to a common electrical one. A
 living

living torpedo was laid on a table, upon a wet napkin; round another table stood five persons insulated; and two brass wires, each thirteen feet long, were suspended from the ceiling by silken strings. One of the wires rested by one end on the wet napkin; the other end was immersed in a basin full of water, placed on a second table, on which stood four other basins, likewise full of water. The first person put a finger of one hand into the water in which the wire was immersed, and a finger of the other hand into the second, and so on successively till all the five persons communicated with one another by the water in the basins. In the last basin one end of the second wire was dipped, and with the other end Mr. WALSH touched the back of the torpedo, when the five persons felt a shock, differing in nothing from that of the Leyden experiment, except in being weaker. Mr. WALSH, who was not in the circle

circle of conduction, felt nothing. This was several times successfully repeated, even with eight persons; and the experiment being related by M. DE SEIGNETTE, mayor of the city, and one of the secretaries of the Academy of Sciences of Rochelle, and published by him in the French Gazette, the account becomes the more authenticated. For though we place full confidence in the candour and veracity of our worthy Brother, yet, in the eyes of the Public, the evidence must be strengthened by the testimony of those, who, but for the sake of truth and science, were no wise interested in the matter. We are therefore the more obliged to Mr. WALSH, for having made these experiments *not in a corner*, but I may say, before the world; and in that very country which gave birth to the celebrated M. DE REAUMUR, whose reputation as a philosopher could not but suffer some diminution, in proportion to

the credit gained at this time by the fortunate stranger. And indeed the whole behaviour of the learned academicians, first at Rochelle, and afterwards at Paris (when the experiments became known there) was such to their guest, as shewed them to be on this, as on other occasions, the true lovers of science, emulous, not envious, of the reputation of their neighbours.

BUT though no farther evidence be wanting to authenticate the experiments of Mr. WALSH, yet, for the confirmation of the conclusions he draws from them, it is with pleasure that I can join the testimony of our learned and candid Brother, Dr. INGENHOUSZ, physician to their Imperial Majesties at Vienna, who, being in Italy when he received a general account of Mr. WALSH's success, at my request repaired to Leghorn, to make some experiments himself upon the torpedo. How far they
agreed

agreed with, and corroborated those of Mr. WALSH, I need not mention, as you have so lately heard the Doctor's Letter to me on that subject.

NOR shall I return to enter into any farther detail of Mr. WALSH's experiments, considering what encroachment I have already made on your time, and how sensible you must be, that those which I have already reminded you of, have merited the honours you are now conferring upon him. I shall only observe, that our ingenious Brother having traced the similitude between the operations of the torpedo and those of an electrical apparatus, he found it so strong, as to persuade him that it was the identical fluid that actuated both the animal and the machine. Yet he remarks, that, though the charged phial occasions attraction and repulsion in such light bodies as the pith-balls, placed near it, and its

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discharge

discharge is obtained through a space of air, and accompanied with light and sound ; nothing of this occurs with respect to the torpedo. But to these objections against a perfect agreement between the electrical and torpedinous fluids, Mr. WALSH answers, that, upon charging a number of large jars with a small quantity of electric matter, and then discharging them, that matter will yield the appearances of the torpedo only. It will not now pass the hundredth part of that inch of air, which in its collected state it would run through with ease ; the spark and snap and the attraction and repulsion of the balls will also be wanting ; nor will a point, brought however near, if not just in contact, be able to draw off the charge ; and yet this diffused electric matter, to effect its equilibrium, will instantaneously pass through a considerable circuit of different conductors properly connected, and give a sensible

flock to such persons as compose the circle. But where is that large surface of diffused electricity to be found in the torpedo? Mr. WALSH replies, that from a minute division of parts a large surface will arise; and that even our naked eye will tell us, that those singular tubulated organs of the torpedo consist, like our electric batteries, of many bodies of a prismatic form, whose surfaces, taken together, compose a considerable area. To this argument we may add, that hitherto no difference has been found, excepting with regard to more and less, between the electric matter which is drawn from the clouds, and that other which pervades all terrestrial bodies, and is collected by every apparatus. If therefore between lightning itself, and the charge of a Leyden Phial, there is no specific difference, nay scarcely a variety, as far as is known, why then should we unnecessarily multiply species, and suppose the torpedo

provided with one different from that which is every where else to be found? But leaving this question to be more thoroughly handled by subsequent experiments, let us conclude, that such has been the similitude established between the electrical fluid of the torpedo, and that of Nature at large, that, in a physical sense, they may be considered as precisely the same.

MR. HUNTER has well observed, and I think he is the first who has made the observation, that the magnitude and number of the nerves bestowed on these electric organs, in proportion to their size, must appear as extraordinary as their effects; and that, if we except the important organs of our senses, there is no part even of the most perfect animal, which, for its size, is more liberally supplied with nerves; nor yet do these nerves of the electric organs seem necessary for any sensation that can belong to them,

them. And with respect to action, he observes, that there is no part of any animal, however strong and constant its action may be, which enjoys so large a proportion of them. If then it be probable, that these nerves are unnecessary for the purpose either of sensation or action, may we not conclude that they are subservient to the formation, collection, and management of the electrical fluid, especially as it appears, from Mr. WALSH's experiments, that the will of the animal commands the electric powers of its body?

IF these reflections be just, we may with some probability foretell, that no discovery of consequence will ever be made by future physiologists, concerning the nature of the nervous fluid, without acknowledging the lights they have borrowed from the experiments of Mr. WALSH upon the living torpedo, and the dissection of the dead animal

by Mr. HUNTER. But whether this will be the individual effect or not, philosophy, by these curious and successful researches, has made a valuable acquisition ; since we may be assured, that whatever tends to disclose the *causæ rerum*, the secret laws of Nature, cannot ultimately fail of subjecting her, more or less, to the uses of life ; and of manifesting, more and more, the wisdom and power of the Creator in all his works,

MR. WALSH,

IN consequence of the approbation of the choice made by the Council, so unfeignedly expressed in the countenance of every gentleman present, it remains that, in the name and by the authority of the Royal Society of London, formed for the
improvement

improvement of Natural Knowledge, I deliver into your hand this Medal, the prize you have so meritoriously obtained ; not doubting, SIR, of your grateful acceptance of so honourable and unperishing a memorial of their esteem, and of the sense of their obligations to a person, who, in so distinguished a manner, has contributed to promote the great ends of their institution. And, in the same respectable name, let me add, that they are so much persuaded of your abilities to assist in their grand work, the *Interpretation of Nature*, that they earnestly call upon you to continue your liberal and spirited labours. With pleasure they understand that you have already turned your views to the electric gymnotus, that other wonder of the waters, an animal possessed of powers similar to those of the torpedo, but of superior energy ; and the Society flatter themselves, that so much light will be gained by that inquiry,

that you will be enabled soon to make a farther discovery of the mysteries of Nature. Her veil fear not, SIR, to approach *. Animated with the presence of this illustrious and successful Body, I will venture to affirm, that Nature has no veil, but what time and persevering experiments may remove. In the instance before us, view the progress of the powers of the mind; view the philosophers of the early ages, like the “children of the world †,” amused and satisfied with the stories of the torpedo; as incurious about their authenticity, as about the causes of such extraordinary effects. This animal served them for an emblem, or an hieroglyphic, for a figure of speech, or an allusion of pleasantry; at best as a theme for a copy of verses. But the

* Alluding to that passage in Mr. WALSH's Paper, “We here approach to that veil of Nature, which “Man cannot remove.”

† Lord BACON.

World, rising in years and in wisdom, rejects such trifles. The Interpreters of Nature, in the adult state of Time, make experiments and inductions, distrust their intellects, confide in facts and in their senses: and by these arts drawing aside the veil of Nature, find a mean and groveling animal armed with lightning, that awful and celestial fire, revered by the ancients as the peculiar attribute of the father of their gods.

卷之四

一、論學問之要
二、論道德之基
三、論經濟之理
四、論政治之制
五、論法律之權
六、論教育之方
七、論宗教之義
八、論藝術之妙
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A
D I S C O U R S E
ON THE
ATTRACTION OF MOUNTAINS;

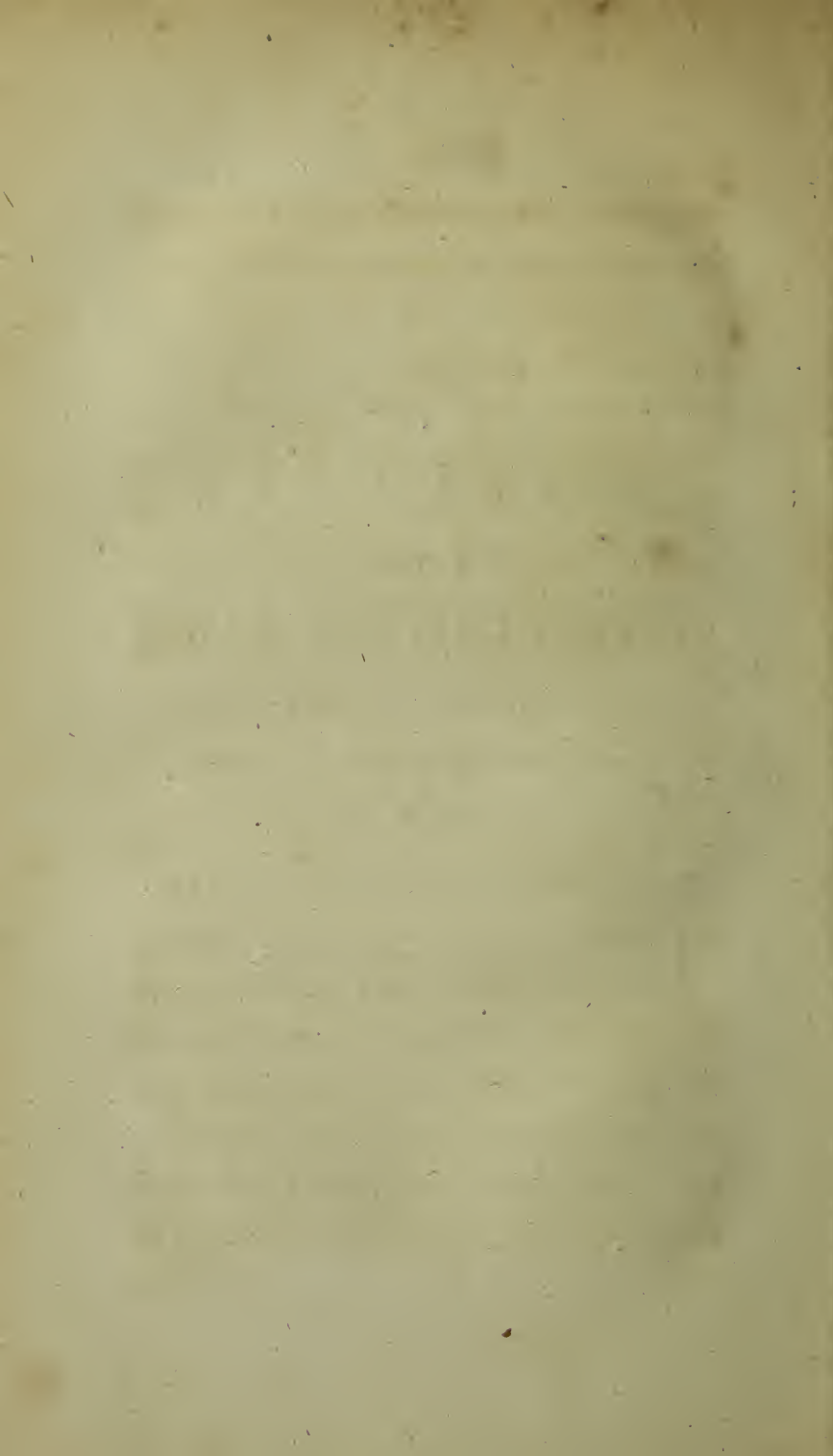
DELIVERED AT THE

Anniversary Meeting of the ROYAL SOCIETY,

November 30, 1775.

By Sir JOHN PRINGLE, Bart. PRESIDENT.

PUBLISHED BY THEIR ORDER.





A
DISCOURSE
ON THE
ATTRACTION OF MOUNTAINS.

GENTLEMEN,

THE satisfaction you discovered when
a proposal was laid before you, *for*
measuring the attraction of mountains, and
the manner in which you received the ac-
count of what had been done to fulfil that
view, were such indications of your ap-
plause, that your Council, ever attentive to
your

your sentiments, have adjudged the Prize-medal of this year to the Reverend NEVIL MASKELYNE, his Majesty's Astronomer at Greenwich, the author and conductor of that experiment. The many and valuable communications of our worthy Brother, preceding this inquiry, you have never failed to distinguish: but these his late labours, undertaken at your request, with their successful result, related in his Paper, intitled, *Observations made on the Mountain Schiehallien for finding its Attraction*, and inserted in the second part of the volume of your Transactions for this year, seemed to lay the Society under such obligations, as your Council presumed you could not otherwise express than by the highest mark of your approbation. In consequence of this reflection, I have, by their authority, caused Mr. MASKELYNE's name, with the date of the present year, to be engraven on the Medal, in order to perpetuate to him

the

the honour you were this day to confer upon him ; if, after allowing me to recal to your remembrance some of the more interesting particulars of this disquisition, and his operations, you should not refuse your sanction to the judgment of your Council.

I SHALL not consider the subject of attraction at large, nor touch upon any species of it, excepting what in latter times, by the effects, has been distinguished by the name of *gravity* or *gravitation* ; a property of bodies, perceptible to the vulgar, when things fall to the ground, but long acknowledged by this Society, to be a quality impressed by the Creator on all matter, whether of the earth or of the heavens, whether at rest or in motion : *He commanded, and it was created.*

THE discovery of this extensive principle, the physics of astronomy, depended
upon

upon a just notion of the arrangement and motions of the spheres ; for, to understand their œconomy, it was necessary previously to know, which of the stars were quiescent, which moved, and in what manner. Whoever therefore found out the true celestial system, might be said to have paved the way to the knowledge of that sublime truth, the law by which the natural world is governed. But who were the inventors here ? Were they Chaldeans or Ægyptians ? Was it PYTHAGORAS, or PHILOLAUS, or any other Greek, either in their own country, or transplanted to the mathematical schools of Alexandria ? I shall not enter upon that enquiry, as fruitless as obscure. All that is clear and to our purpose, is, that some of the ancient Greeks conjectured rightly about the stability of the Sun, and the circular motion of the earth ; but this was never a general persuasion, nor does it seem to have been mentioned any more after the

age of PTOLEMY, who in the second century did not so much invent a new system, as adopt that which now goes under his name, the prevailing one of his time, and nearly the same with that of ARISTOTLE. This, though erroneous, was not, perhaps, incapable of improvements from celestial observations ; but when the philosophy of the schools was united with the Ptolemaic hypothesis, and both were subjected to judicial astrology, then was astronomy debased to the level of the pretended learning of the dark ages that ensued, and increased their darkness.

BUT at the appointed time, when it pleased the Supreme Dispenser of every good gift to restore light to a bewildered world, and more particularly to manifest his wisdom in the simplicity as well as in the grandeur of his works, he opened the glorious scene with the revival of a sound

H astronomy.

astronomy. COPERNICUS of Thorn (a Polish city in the Regal Prussia), endowed by Nature with excellent talents, improved by a superior degree of mathematics, and by travelling, became, early in life, disgusted with the contradictions about the cause of the celestial phænomena. He had recourse, as he himself informs us*, to every author upon the subject, to see whether any had been more consistent in explaining the irregular motions of the stars, than the mathematical schools; but received no satisfaction, till first, from CICERO, he found that NICETAS had maintained the motion of the earth; and next, from PLUTARCH, that others of the ancients had been of the same opinion. CICERO had said that ‘NICETAS the Syracusan (according to THEOPHRASTUS) held that the heavens, the sun, the moon, the stars, in

* Præf. ad Lib. de Revolutionibus Orbium Cœlestium.

‘ a word,

‘ a word, all the celestial bodies, stood still,
 ‘ and that, excepting the earth, nothing
 ‘ moved in the world ; but that, whilst
 ‘ the earth with the greatest celerity turned
 ‘ round its axis, the same phænomena
 ‘ were produced as if it stood still, and the
 ‘ heavens moved. And this some thought
 ‘ was also PLATO’s notion, but somewhat
 ‘ obscurely expressed*.’

PLUTARCH’s words were, ‘ Others sup-
 ‘ pose the earth to be at rest ; but PHILO-
 ‘ LAUS, the Pythagorean, that it is carried
 ‘ in the ecliptic round the fire, like the
 ‘ sun and the moon. HERACLIDES of
 ‘ Pontus, and ECPHANTUS the Pythago-
 ‘ rean, make the earth move like a wheel
 ‘ about its centre, from west to east, but
 ‘ not to change its place †.

* Cicer. Quæst. Academic.

† Placit. Philos. lib. iii. cap. 3.

FROM these quotations, and what COPERNICUS farther says*, we find how little disposed that great man was to plume himself with the inventions of others: nay, he was rather anxious not only to do justice to those who had gone before him, but by their authority to screen himself from the censure of innovation, absurdity, and impiety, that awaited the publication of his doctrine. After all, the original genius of COPERNICUS was but little beholden, for the discovery of those sublime truths, to either NICETAS or PLATO, since it appears, from CICERO, that these two believed both the moon and the planets to be motionless. Nor could he be more assisted by PHILOLAUS, who taught that *the earth turned round a fire*; but this fire could not be the sun, because that Ancient compares the motion of the earth about *the fire*, to the revolution of the sun

* Placit. Philos. lib. iii. cap. 3.

and moon about the earth. Lastly, what little light COPERNICUS could draw from HERACLIDES and ECPHANTUS, I scarcely need say, since they, though admitting the diurnal motion of the earth, denied the annual.

BUT if COPERNICUS sought to do justice, why did he not rather cite a clear and express passage in the Arenarius of ARCHIMEDES, for the fixed state of the sun, and for the motion of the earth in a circle round his body? ‘What most philosophers
 ‘ call the world,’ says that famous Ancient,
 ‘ is a sphere, of which the centre is that of
 ‘ the earth, and whereof the semi-diameter
 ‘ is equal to a right line joining the centers
 ‘ of the earth and the sun. But ARIS-
 ‘ TARCHUS the Samian, refuting this opi-
 ‘ nion, has advanced an hypothesis, where-
 ‘ by the world should be many times
 ‘ greater than what is here said; for he

‘ supposes that the fixed stars and the sun
 ‘ remain immoveable, and that the earth
 ‘ is carried in a circle round the sun, placed
 ‘ in the middle of its course *.’

THUS far ARCHIMEDES, who seems not to disapprove the system, but who explains it no farther, as what he had quoted was sufficient for his purpose. It is probable that the penetrating genius of ARISTARCHUS had discovered the true arrangement of all the celestial bodies, and thereby totally anticipated COPERNICUS; but that circumstance is no where, that I know of, recorded; and otherwise, we should acquit our illustrious Reformer of plagiarism, with regard to ARISTARCHUS, since neither the Arenarius of ARCHIMEDES, where that passage is found, nor indeed any other of his valuable remains, had seen the light before the death of COPERNICUS. This

* Archimed. Arenar. ed. Oxon. 1676.

extraordinary person had, even before the meridian of life, completed his discoveries, and comprised them in his book *De Revolutionibus Orbium Cælestium*, his only work ; but which he had prudently suppressed, till he had maturely considered his subject, and had found a necessary and powerful patron, the pope himself, PAUL III., a lover of astronomy, to protect him. Alluding to the admonition of the Poet, he tells the Pontiff, ‘ he had suffered that fruit of his labours to ripen, not nine years only, but four times nine*.’ Consenting at last to the publication, he committed the care of the impression to some friends in a distant city, from whom he received the finished copy a few hours before he expired†.

FEW compositions have destroyed more riveted errors, or established more import-

* Præfat. ad Lib. de Revolut.

† Gassend. in Vita Copernic.

ant truths. Here, instead of an absolute state of rest for the earth, its triple motion is ascertained, the diurnal about its axis, the annual about the sun, and that other, known by the term *precession of the equinoxes*; all which, till then, had been referred to the motion of the heavens. He likewise demonstrated the double orbit of the moon; that is, her menstrual motion about the earth, and her annual about the sun. Nor did the wise COPERNICUS stop here: for, after laying this solid foundation of the celestial physics, he began the superstructure, by furnishing a principle of *attraction* to be inherent in all matter. Thus, in refuting the peripatetic notion, that bodies fall to the ground, because, by a law of Nature, every thing heavy tends to the centre of the universe (which they supposed to be in the centre of the earth), he observed that ‘ the earth could not be the centre of the orbits of several of the planets,

‘ nets, because of the apparent irregulari-
 ‘ ties of their motions, and therefore could
 ‘ not be the centre of the universe. Hence,
 ‘ according to these philosophers, there
 ‘ must be more centres than one; and if
 ‘ so, who could tell the true centre, toward
 ‘ which all bodies were to gravitate? As
 ‘ for gravity (says he), I consider it as
 ‘ nothing more than a certain natural ap-
 ‘ petence (*appetentia*), that the Creator
 ‘ has impressed upon all the parts of mat-
 ‘ ter, in order to their uniting and coa-
 ‘ lescing into a globular form, for their
 ‘ better preservation; and it is credible
 ‘ that the same power is also inherent in
 ‘ the sun, and moon, and planets, that
 ‘ those bodies likewise may constantly re-
 ‘ tain that round figure in which we be-
 ‘ hold them*.’ Farther, COPERNICUS
 looked upon the sun as the chief governing
 power of the earth and all the other pla-

* De Revolut. Orb. Cœlest. lib. i. cap. 9.

nets ; for, after placing the great luminary in the centre, he cries out with rapture, ‘ *Profectò tanquam in folio regali sol residens* ‘ *circumagentem gubernat astrorum fami-* ‘ *liam* *.’ Nor was this government understood to be exercised by any other power than that of *attraction* ; as may be inferred from some of the last words of the celebrated TYCHO BRAHE, who, perceiving the approach of death, called for the famous KEPLER (then a young man, and his assistant in his observatory at Prague), and after charging him with completing and publishing the astronomical tables which he was leaving unfinished, thus addressed him : ‘ My friend, although what ‘ I ascribe to a voluntary, and, as it were, ‘ an obsequious motion of the planets ‘ round the sun, you attribute to an *at-* ‘ *tractive* energy of that body ; yet I must ‘ entreat you, that, in the publication of

* De Revolut. Orb. Cœlest. lib. i. cap. 10.

‘ my observations, you would explain all
 ‘ the celestial motions by my hypothesis,
 ‘ rather than by that of COPERNICUS,
 ‘ which I know you would otherwise in-
 ‘ cline to follow *.

FROM this passage, which I have taken from the life of TYCHO BRAHE, it would seem, that though that other excellent astronomer was not insensible of some influencing power of the sun over the planets, he would not however express it by so strong a term as *attraction*. But in what manner KEPLER complied with the request of his dying patron, it is not our present purpose to mention, and therefore we shall only observe, that in his own works he constantly maintains the doctrine of attraction, and carries it even farther than ever COPERNICUS had done. Thus he calls gravity *a corporeal and mutual affection*

* Gassend. in Vit. Tych. Brah. cap. 5.

between similar bodies, in order to their union *. Again he remarks with COPERNICUS, against the peripatetics, that ‘ heavenly bodies do not tend to the centre of the universe, but to the centre of those larger round bodies, of which they make a part; so that, if the earth were not spherical, things would not fall from all points towards its centre. If a stone were to be placed at a distance from another stone, in any part of the universe, without the sphere of action of a third body, like two magnets, they would come together in some intermediate point, each advancing, in space, in the inverse proportion of their quantities of matter. Hence, if the moon and the earth were not by some power kept asunder in their respective orbits, they would move towards one another; the moon making fifty-three parts of the way, while the

* Astron. Nov. in Introduct.

‘ earth made one, supposing their densities
 ‘ equal *.’

FROM the same principle KEPLER accounted for the general motion of the tides; to wit, by the attraction of the moon, and expressly calls it *virtus traëtorïa quæ in luna est* †. He adds, that if the earth did not exert an attractive power over its own waters, they would rise and rush to the moon ‡. Farther, we find him suspecting certain irregularities in the motion of the moon to be owing to the combined action of the earth and sun upon its body §. These, and other reflections concerning the universality of attraction, he accompanies with an ingenious anticipation of a law of Nature, from conjecture only, but which was afterwards made out by experiments. The schools had taught, that

* Astron. Nov. in Introduct. † Ibid.

‡ Ibid. § Astron. Nov. cap. xxxvii.

‘ some

‘ some bodies were by their nature heavy,
 ‘ and so fell to the ground, and that others
 ‘ were by their nature light, and therefore
 ‘ mounted upwards:’ but KEPLER pronounced that ‘ no bodies whatsoever were
 ‘ absolutely light, but only relatively so;
 ‘ and, consequently, that all matter was
 ‘ subjected to the law of gravitation*.’

HITHERTO the genius of KEPLER had been fortunate, in tracing out that great principle, which hindered the planets from flying off from the sun: But what kept them from falling into that mass of fire, and what power perpetuated their motion in their orbits? Here his sagacity had failed him, and left his imagination to furnish the idea of a system of *vortices* for DESCARTES.

BUT howsoever incomplete these notions were concerning gravitation, yet, in justice

* Astron. Nov. in Introduct.

to their distinguished authors, COPERNICUS and KEPLER, I thought proper to commemorate them on this occasion, as none before them had expressed themselves so fully, and with so much truth, on that curious subject : and as none, from their days to those of Dr. HOOKE, made any such improvement, as would apologize for my taking up so much more of your time in recalling their sentiments to your remembrance, let it suffice to mention, that the first who, in this country, embraced that doctrine, was Dr. GILBERT*, but who did not properly distinguish between attraction and magnetism ; and that the next was Lord BACON, who, though not a convert to the *Copernican* system, yet acknowledged an attractive power in matter †. In France, we find FERMAT and

* De Magnete.

† Nov. Organ. lib. ii. aphor. 36. 45. 48. Sylvar. cent. i. exp. 33.

ROBERVAL, mathematicians of great eminence, of the same opinion*; and in Italy, BORELLI, after GALILEO†, who was the first in that country who conceived that idea, but far from that precision and extension we find it in his contemporaries BACON and KEPLER.

BEFORE we pass from KEPLER, it will be proper to observe, that this great improver of astronomy did not, perhaps, after all, contribute so much to the advancement of this theory, by those conjectures which I have related, as by some astronomical deductions from TYCHO BRAHE's observations, since known by the name of KEPLER's *Laws*. The first was, that the planets move not in circular, but in elliptical orbits, of a small eccentricity, whereof the centre of the sun makes one of its *foci*.

* Montucla Hist. des Mathem. part iv. liv. viii.

† Syst. Cosmic.

The second, that the same planet describes about the sun equal areas in equal times. The third, that in different planets, the squares of the periodic times are as the cubes of their mean distances from the sun.

SUCH were the preparatives to the true philosophy, and indeed excellent materials for the architect then unborn. But till Sir ISAAC NEWTON appeared, notwithstanding the numerous and momentous discoveries that had been made in the heavens, by COPERNICUS, TYCHO BRAHE, GALILEO, KEPLER, and others, yet astronomy, as Lord BACON complained, still remained but a mathematical study. The passage to which I allude is long; but, as tending to illustrate more than one particular relating to my subject, I cannot forbear trespassing on your indulgence by the citation. ‘ Al-
though astronomy,’ says BACON, ‘ has
I ‘ not

‘ not been founded amiss upon observation
 ‘ of the phænomena, yet the superstructure
 ‘ has hitherto kept low and weakly. In
 ‘ truth that science presents to the human
 ‘ understanding such an object as PROME-
 ‘ THEUS did of old to JUPITER, when,
 ‘ meaning to impose upon that deity, he
 ‘ offered upon his altar, instead of a live
 ‘ victim, the hide of a large bullock,
 ‘ stuffed with straw, leaves, and other
 ‘ branches. In like manner, astronomy
 ‘ exhibits the externals of the celestial
 ‘ bodies, as the cuticular part of heaven,
 ‘ fair, indeed, and artificially formed into
 ‘ a system; but the entrails and the foun-
 ‘ tains of life are wanting, that is, the
 ‘ physical causes and reasons; from which,
 ‘ and from astronomical hypotheses, a the-
 ‘ ory should be drawn, not adequate only
 ‘ to account for all the phænomena, but
 ‘ for the substance, the motion, and influx
 ‘ of the heavens, as they are in Nature.—

‘ Scarcely is there one to be found, who
 ‘ has enquired into the natural causes;
 ‘ either of the substance of celestial matter,
 ‘ or into the reason of the swiftness or
 ‘ slowness of the heavenly bodies acting
 ‘ upon one another; or into the various
 ‘ degrees of motion of the same planet, or
 ‘ into the motion from east to west, or of
 ‘ the contrary direction; nor into the pro-
 ‘ gressions, stations, and retrogradations of
 ‘ those bodies; nor into the causes of the
 ‘ apogæum and perigæum.—I say, inqui-
 ‘ ries of this kind have scarcely been at-
 ‘ tempted, nor indeed any labour bestowed
 ‘ upon the subject, excepting in the way
 ‘ of mathematical observations and demon-
 ‘ strations. So that astronomy, such as it
 ‘ now is, can only be reckoned among the
 ‘ mathematical arts; not without consider-
 ‘ able diminution of its dignity, since, were
 ‘ it to maintain its rights, it might rank
 ‘ itself as the noblest branch of philosophy.

‘ For he that shall reject the fictitious di-
 ‘ vices between the superlunary and sub-
 ‘ lunary bodies, and shall duly attend to
 ‘ the appetences and most general affections
 ‘ of matter (which both in the earth and
 ‘ in the heavens are exceedingly powerful,
 ‘ and indeed pervade the universe), will
 ‘ receive, from what he sees passing on the
 ‘ earth, clear information concerning the
 ‘ nature of celestial bodies; and contrari-
 ‘ wise, from motions which he shall disco-
 ‘ ver in the heavens, will learn many par-
 ‘ ticulars relating to the things below, that
 ‘ now lie concealed from us. Wherefore
 ‘ the physical part of astronomy we mark
 ‘ as *wanting*, and call it the *astronomia*
 ‘ *viva*, the animated astronomy, in oppo-
 ‘ sition to the stuffed bullock of PROME-
 ‘ THEUS*.’

THE great *desideratum* was supplied, and from the bosom of this Society, in the

* De Dign. & Augm. Scient. l. iii. c. 4.

publication of the *Principia*, the immortal work of NEWTON. There the illustrious author evinces truths that had been only surmised before ; and, after establishing by a just analysis the laws of attraction, in a synthetical method proceeds to explain by them the motions and appearances of the heavenly bodies. Had not NEWTON lived, BACON might have passed for a visionary speculator ; but since the demands of that noble author upon the human intellects have been so fully answered in the productions of Sir ISAAC NEWTON, shall we not reverence those powers of his own mind, that could, in that dawn of philosophy in which he lived, so well descry what parts were wanting, and what were the means of attaining them ?

NEWTON, in a posthumous treatise, *de Systemate Mundi*, composed before the
I 3 publication

publication of the *Principia*, and mentioned there, has said, that ‘ some of the latter
 ‘ philosophers had sought to account for
 ‘ the course of the planets in their orbits
 ‘ by the action of certain *vortices*, as KEP-
 ‘ LER and DESCARTES ; or by some other
 ‘ principle of impulse or attraction, as BO-
 ‘ RELLI, HOOKE, and others of our na-
 ‘ tion.’ From this passage it would seem that, in those times, there had been more conjectures formed concerning attraction, than what were published ; for, excepting GILBERT, who vainly attempted to explain the mundane system by magnetism, and Lord BACON, who never acceded to the *Copernican* hypothesis*, I have found none of our nation, HOOKE excepted, who, in this way, have left any thing on record

* ‘ Atque harum suppositionum absurditas, in motum terræ diurnum, (*quod nobis constat falsissimum esse*) homines impegit.’—Bac. de Dign. & Augm. Scient. lib. iii. cap. iv.

worthy of your notice. He, indeed, the early, the ingenious, and most useful member of this Society, advanced, in this research, far beyond all that had gone before him. But I shall not enlarge upon his improvements, as you have in your hands his *Cutlerian Lectures*, which contain them, and as I have already but too long dwelt on this part of my subject. It will ever redound to the praise of HOOKE, that NEWTON has associated him with himself in maintaining the true regulating cause of the course of the planets*. As to BORELLI, though I have found in one of the pieces (a scarce one) of that learned Italian, a passage that certainly favours attraction; yet as it is neither so full nor so explicit, upon that point, as several others which I have cited, I must suspect that those parts,

* M. MONTUCLA has done great justice to Dr. HOOKE, in this and other particulars, in his excellent work, *Hist. de Mathem.* part iv. liv. 8.

which Sir ISAAC had in his eye, have escaped my observation*.

THE great completer of the doctrine of universal gravitation had the satisfaction to find, from the reception it met with in this Society, that he had not laboured in vain: nay, perhaps no philosophical author was ever more admired and followed, in his own time and in his own country, than NEWTON was in these kingdoms. With regard to others, ‘we are not to wonder,’

* This is the passage alluded to: ‘Præterea manifestum est, quemlibet sive primarium sive secundarium planetam aliquem insignem mundi globum, quasi virtutis fontem, circumdare, qui ita eos stringat atque conglutinat, ut ab ipso nullo pacto abstrahi possint; sed ipsam, quacunque contendentem, perpetuis continuisque orbibus cogantur consequi: videmus enim Saturnum, Jovem, Martem, Venerem, atque Mercurium, Solem ipsum,—Medicæ Sidera, Jovem,—Hugenianumque Sidus, Saturnum circumire, non secus, ac circa Telluris Globum Luna ipsa revolvitur.’—Joa. Alph. Borelli Theor. Medic. Planetar. ex Causis Physicis deductæ, lib. i. cap. ii. p. 5. Florent. 1666, 4to.

as remarked by his eloquent Eulogist, ‘ if
 ‘ philosophers, upon the first publication
 ‘ of the *Principia*, took the alarm at the
 ‘ term *attraction*, as fearing the return of
 ‘ the *occult qualities*; or if, considering the
 ‘ difficulty of the subject, and the few
 ‘ words employed in explaining it, they
 ‘ wanted time fully to comprehend it*.’
 These obstacles have been removing by
 degrees, and the way at last has been so
 effectually cleared, that the name of NEW-
 TON is not perhaps held in more estima-
 tion here, nor his principles more cordially
 embraced, than in those very societies of
 the learned abroad, which at first shewed
 most unbelief, and at whose conversion,
 therefore, we ought most to rejoice.

THE Royal Academy of Sciences, whilst
 in an uncertain state between the old and
 new system of philosophy, having, for one

* *Eloge de Newton, par M. de Fontenelle.*

of the decisive experiments, measured some degrees of latitude upon an arch of a meridian passing through Paris, and compared this mensuration with others, inferred the earth to be a spheroid, with the longest diameter passing through its poles; but, sensible that this operation had not been so unexceptionably conducted as to satisfy either the followers of NEWTON or those of HUYGENS, who both required a spheroid flattened at the poles, resolved upon a farther and more accurate trial. With this view, in the year 1735, some chosen members from that illustrious Body were sent to the polar circle, and others to the equator; at which places the differences of degrees being greater, the point in dispute might be determined with less danger of error. How much to the honour of NEWTON and HUYGENS the result was, is sufficiently known. All that is necessary to be mentioned here, is, that, in the year

1738,

1738, whilst the academicians were still in Peru, it occurred to M. BOUGUER, one of that number, to put the *Newtonian* system to another test, by enquiring into the attraction of mountains. This idea, which was originally from NEWTON himself, M. BOUGUER communicated to his colleague M. DE LA CONDAMINE, who readily assisted in making the trial *. Those gentlemen were persuaded, that if the whole mass of the earth were really possessed of such a property, a high mountain, such as Nature had abundantly provided in that country, would shew some proportionable degree of it; and that the largest of the Andes was indeed but a small object in comparison of the earth: nevertheless they reckoned, by a rough computation, that the attraction of Chimborazo, which they deemed the best for their purpose, would

* BOUGUER, *Figure de la Terre*, sect. 7. DE LA CONDAMINE, *Journal du Voyage à l'Equateur*.

be equal to about the 2000th part of the attraction of the whole earth. Now, here the mountain acting as one, whilst the earth acted as 2000, the direction of gravity would be visibly turned out of the vertical line, for as much as this direction would be $1'$ and $43''$ towards the mountain. But how was this deflexion to be estimated? Only by finding the quantity of deviation of the plumb-line from a vertical position, by means of stars. In order to attain this point, they found it most convenient, in their present circumstances, to take the distance of several stars from the zenith, at two stations, one on the south side of Chimborazo, and the other a league and a half to the west; that is, at such a distance from the first station, as that the plumb-line should be but little affected by the mountain. This disposition being made, they proceeded to their operations, of which we have a full and clear account by M.

BOUGUER,

BOUGUER, in his valuable treatise entitled *Figure de la Terre*; but of M. DE LA CONDAMINE, we have only a short abstract of the narrative he presented to the Academy; which abstract is contained in his curious *Journal of a Voyage to the Equator*.

FROM both it appears, that though these learned persons, during the time employed in this experiment (which the inclemency of the air, at that height in the atmosphere, forced them to make very short),—I say, though during this time they spared no pains, yet their observations not only varied from one another, but seemed to be little satisfactory to themselves. M. BOUGUER says, that, instead of $1^{\circ} 43''$, which the plumb-line ought to have declined from the true vertical line, the total declension amounted only to seven seconds and a half: an effect that fell far short of the
 expecta-

expectations of a *Newtonian*. But those candid gentlemen take notice, that, ‘ as on
 ‘ one hand we are ignorant of the density
 ‘ of the internal parts of the earth, which
 ‘ may be considerably greater than what
 ‘ appears by its surface; so, on the other,
 ‘ Chimborazo, which they believed likely
 ‘ to be as solid as any other parts of the
 ‘ surface of the earth, might nevertheless,
 ‘ in many places, be hollow.’ Nay, M.
 DE LA CONDAMINE tells us, that ‘ he was
 ‘ afterwards informed of a tradition in the
 ‘ country, that this very mountain had
 ‘ once been a volcano;’ and adds, that
 ‘ whilst he and his colleague were about
 ‘ their experiment, they had actually found
 ‘ some calcined stones upon it:’ from which
 circumstances he infers, that ‘ if one cannot
 ‘ just draw from this trial an absolute proof
 ‘ of the *Newtonian* attraction, one can far
 ‘ less form any conclusion against it.’ M.
 BOUGUER goes farther, and observes, that
 ‘ if

‘ if we will be satisfied with the bare fact,
 ‘ it is certain, from this experiment, that
 ‘ mountains do act at a distance, but that
 ‘ their action is much less than what might
 ‘ be expected from their bulk.’ He con-
 cludes his account in the true spirit of a
 philosopher, by saying, that ‘ as in France,
 ‘ or in England, a hill may be found of a
 ‘ sufficient height for the purpose, and
 ‘ especially if the observer would double
 ‘ the action, by making a station on each
 ‘ side ; he should be happy to hear, on his
 ‘ return to Europe, that the experiment
 ‘ had been repeated, whether the result
 ‘ tended to confirm his observations, or to
 ‘ throw some better light upon that en-
 ‘ quiry.’ If the Society have fulfilled the
 views of that worthy man, who thus called
 upon them, we have to regret that he did
 not live long enough to share the satisfac-
 tion with us.

I COME

I COME now to Mr. MASKELYNE's labours, upon which I shall not expatiate, as I have already taken up too much of your time, and as I judge it unnecessary to dwell long upon that part of my subject, which you have so lately heard in his own words, and which you will have in a few days published at large in your Transactions.

I NEED only remind you, that the zenith distance of a star on the meridian being observed at two stations under the same meridian, one on the south side of a mountain, the other on the north; if the plumb-line of the instrument be attracted by the mountain out of its vertical position, the star will appear too much to the north, by the observation at the southern station, and too much to the south, by that at the northern station; and consequently the difference of the latitudes of the two stations will be found, by these observations,

greater

greater than it really is. And if the true difference of their latitudes be determined by measuring the distance between the two stations on the ground, the excess of the difference, found by the observations of the star, above that found by this measurement, must have been produced by the attraction of the mountain, and its half will be the effect of such attraction on the plumb-line at each observation, supposing the mountain attracts equally on both sides.

To perform this experiment, Mr. MASKELYNE made choice of the mountain Schehallien, in Perthshire in North Britain, of which the direction in length is nearly east and west; its height above the surrounding valley, at a medium, is about 2000 feet; and its highest part, above the level of the sea, is 3550 feet. As the greatest attraction of the mountain was to

be expected about half way up its sides (which happened, conveniently for the purpose of the experiment, to be pretty steep), two stations for an observatory were accordingly chosen, one on the north, the other on the south side of Schehallien. The instrument, with which he observed the stars, was an excellent sector made by Mr. Sisson; and Mr. MASKELYNE has related at large all the precautions he took both for adjusting this instrument in the meridian at each station, and for satisfying himself that the line of collimation remained unaltered. From observations of ten stars near the zenith, he found the apparent difference of the latitudes of the two stations to be $54''$, 6; and from a measurement by triangles, formed from two bases on different sides of the mountain, he found the distance of their parallels to be 4364 feet, which, in the latitude of Schehallien, viz. $56^{\circ} 40'$, answer to an arch of the meridian

ridian of $43''$: this is $11''$, 6 less than that found by the sector. Its half, therefore, $5''$, 8, is the mean effect of the attraction of the mountain: and from its magnitude, compared with the bulk of the whole earth, Mr. MASKELYNE discovered the mean density of the earth to be about double that of the mountain.

IN the execution of this interesting experiment, our worthy brother has not only exerted a patience and perseverance, but a sagacity and judgment, which must ever redound to his honour. All doubts about an universal attraction must at last be terminated, and every philosopher, in that respect, must now become a *Newtonian*.

IF I have related but two experiments that have been made, the first by the French academicians, and the other by

Mr. MASKELYNE, it is because no more have come to our knowledge ; nor do I believe that more have actually been executed. For if, in occasional mensurations of degrees of the meridian in different parts of Europe, those employed have found varieties arise in their measures, that they could not otherwise account for, than from the attraction of the mountains among which they carried on their operations, and accordingly have referred those irregularities to that very cause ; such conjectures we admit may be well founded, but the measurements whence they arise we cannot reckon among the experiments we now treat of.

BUT was not the doctrine of an universal attraction so fully demonstrated by NEWTON, as not to require any farther proofs from experiments ? Demonstrated it was, but not to the conviction of every individual.

individual. True Philosophy condescends to adapt her instructions to different capacities, and is as willing to inform by palpable experiments as by geometrical demonstrations. But to say the truth, something seemed wanting here for the satisfaction of even the more enlightened minds. Such we reckon those were, who first made the trial. And did not HUYGENS himself, one of the greatest philosophers and geometricians of his age, find difficulties about this principle, even after the publication of NEWTON's *Principia*? Nor do we learn that the doubts of that great man were ever removed*. To say nothing of the celebrated LEIBNITZ, and his numerous followers, who to this day are either wholly unbelievers in attraction, or at best but sceptics on that article.

YOU have, therefore, GENTLEMEN, the satisfaction to think that you have com-

* Vid, Huygen. Differt. de Caus. Gravitat.

pleted a great and acceptable work to the scientific world ; and that, though this has been a costly experiment, your gracious PATRON, who so liberally furnished the means, will highly approve your expending his benefaction so much for the advancement of Natural Knowledge and for the benefit of the Public ; and will so much the more be disposed to shew you the like favour on future occasions.

BUT even those who wanted no fresh proofs of the universality of attraction, must still partake of the advantages accruing from this experiment, as being not only the first that has been made, but the best that could be devised, for estimating the mean density of the earth. The operation in Peru was too imperfect for that purpose ; and had the circumstances of that trial been more favourable, yet the suspicion of the mountain's having been
once

once a volcano, was a sufficient reason for admitting no evidence from it in this part of our inquiry. But for Schehallien, as its appearance was particularly rocky, and as several specimens of its rocks have been presented to the Society, and acknowledged to be mineral substances that had never passed through fire, we may consider that mountain as one of the proper patterns of the density of the surface of the earth.

THESE, GENTLEMEN, are the fruits of the operations of Mr. MASKELYNE, during a residence of four months in a mean hut, on the side of a bleak mountain, and in a climate little favourable to celestial observations. To these inconveniences, however, he submitted with patience and complacency, as he went at your request, and in pursuit of science. You have heard his chief conclusions ; but permit me add, that, as this is a new mine opened in the

field of Nature, I am confident that these will not be the only productions ; but that, as in all great and successful experiments, there will be, in the prosecution of this subject, some valuable truths brought to light, of which at present we can form no particular conjecture. Mean while we have the pleasure to find the doctrine of *universal gravitation* so firmly established by this finishing step of analysis, that the most scrupulous now can no longer hesitate to embrace a principle, that gives life to Astronomy, by accounting for the various motions and appearances of the Hosts of Heaven.

MR. MASKELYNE,

THE judgment, SIR, of the Council,
in awarding you the Prize, having received
the

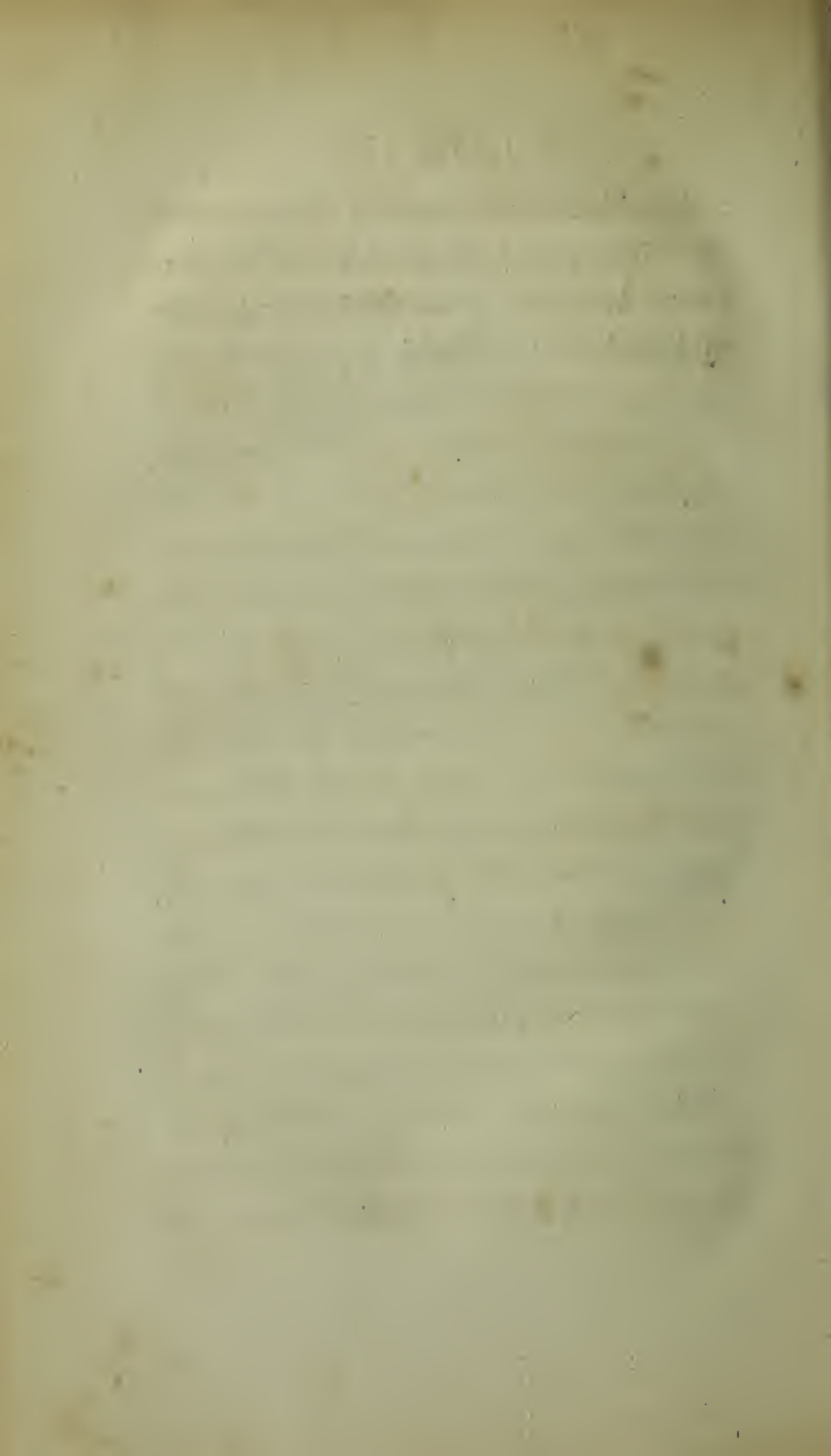
the sanction of the Royal Society, I do, in the name and by the authority of that illustrious Body, present you, their most worthy Brother, with this sincere pledge of their affection; as the lasting token of their acknowledgment for your several ingenious and useful communications, and more particularly for this last painful and capital experiment, which adds no small lustre to their Transactions. And after expressing their grateful sentiments for what you have already done for their service, I would farther say, that they persuade themselves, from your talents, your love of your profession, and your happy period of life, you will continue steadily to pursue that path which you have so early entered upon, and which so surely leads to great and useful discoveries. You have, SIR, in charge the noblest branch of Natural Philosophy: such it has ever been held by this Society,

and

and as such it ever has been cherished and cultivated by them. And they flatter themselves that their cares and solicitude have not been fruitless ; since, from their first institution to this day, there have never been wanting some excellent men in that line, to promote the science, and do honour to this Community. But so transcendently great is that part of the creation, that though the Divine Author has vouchsafed, in these latter days, to open, to the humble and patient inquirers into Nature, the *Causes of Things* ; yet we must still cry with the ancient sage, *Lo, these are part of His ways, but how little a portion is heard of them !* As much then remains to be explored in the celestial regions, you are encouraged, SIR, by what has been already attained, to persevere in these hallowed labours, from which have been derived the greatest improvements in the most useful arts,

and

and the loudest declarations of the power, the wisdom, and the goodness of the Supreme Architect, in the spacious and beautiful fabric of the World.



A
DISCOURSE

UPON

SOME LATE IMPROVEMENTS
OF THE MEANS FOR
PRESERVING THE HEALTH OF MARINERS;

DELIVERED AT THE

Anniversary Meeting of the ROYAL SOCIETY,

November 30, 1776.

By Sir JOHN PRINGLE, Bart. PRESIDENT.

PUBLISHED BY THEIR ORDER.

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A
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PRESERVING THE HEALTH OF MARINERS.

GENTLEMEN,

BEFORE we proceed farther in the business of this day, permit me to acquaint you with the judgment of your Council in the disposal of Sir GODFREY COPLEY's Medal; an office I have undertaken at their request, and with the greater satisfaction, as I am confident you will be

no

less unanimous in giving your approbation, than they have been in addressing you for it upon this occasion. For though they were not insensible of the just title that several of the Papers, composing the present volume of your Transactions, had to your particular notice, yet they did not hesitate in preferring that which I presented to you from Captain COOK, giving *An Account of the Method he had taken to preserve the Health of the Crew of his Majesty's Ship, the Resolution, during her late Voyage round the World*. Indeed, I imagine that the name alone of so worthy a Member of this Society would have inclined you to depart from the strictness of your rules, by conferring upon him that honour, though you had received no direct communication from him; considering how meritorious in your eyes that person must appear, who hath not only made the most extensive, but the most instructive voyages;

ages; who hath not only discovered, but surveyed, vast tracts of new coasts; who hath dispelled the illusion of a *terra australis incognita*, and fixed the bounds of the habitable earth, as well as those of the navigable ocean, in the southern hemisphere.

I SHALL not, however, expatiate on that ample field of praise, but confine my discourse to what was the intention of this honorary premium, namely, to crown that Paper of the year, which should contain the most useful and most successful experimental enquiry. Now what enquiry can be so useful as that; which hath for its object the saving the lives of men? And when shall we find one more successful than that before us? Here are no vain boastings of the empiric, nor ingenious and delusive theories of the dogmatist; but a concise, and artless, and an uncontested relation of the means, by which, ‘ under the

L ‘ divine

‘ divine favour, Captain COOK, with a
 ‘ company of an hundred and eighteen
 ‘ men*, performed a voyage of three years
 ‘ and eighteen days, throughout all the
 ‘ climates, from fifty-two degrees north to
 ‘ seventy-one degrees south, with the loss
 ‘ of only one man by sickness †.’ What
 must enhance to us the value of these salutary observations, is, to see that the practice hath been no less simple than efficacious.

I WOULD now enquire of the most conversant in the study of bills of mortality, whether, in the most healthful climate, and

* There were on board, in all, one hundred and eighteen men, including M. Sparrman and his servant, but whom they took in at the Cape of Good Hope, and left there upon their return to that place.

† This was a consumption terminating in a dropsy. Mr. Patten, surgeon to the Resolution, who mentioned to me this case, observed that this man began so early to complain of a cough and other consumptive symptoms, which had never left him, that his lungs must have been affected before he came on board.

in

in the best condition of life, they have ever found so small a number of deaths, in such a number of men, within that space of time? How great and agreeable then must our surprise be, after perusing the histories of long navigations in former days, when so many perished by marine diseases, to find the air of the sea acquitted of all malignity, and, in fine, that a voyage round the world may be undertaken with less danger, perhaps, to health, than a common tour in Europe!

BUT the better to see the contrast between the old and the present times, allow me to recal to your memory what you have read of the first voyage for the establishment of the East India Company*. The equipment consisting of four ships,

* This squadron, under the command of LANCASTER (who was called the General), set out in the year 1601. See PURCHAS's Pilgr. vol. i. p. 147, & seq.

with four hundred and eighty men on board, three of these vessels were so weakened by the scurvy, by the time they had got only three degrees beyond the Line, that the merchants, who had embarked on this adventure, were obliged to do duty as common sailors ; and there died, in all, at sea, and on shore at Soldania, a place of refreshment on this side the Cape of Good Hope, one hundred and five men, which was nearly a fourth part of their complement, before they got farther on their voyage. And hath not Sir RICHARD HAWKINS, who lived in that age, an intelligent as well as brave officer, recorded, that ‘ in twenty years, during which he ‘ had used the sea, he could give an account of ten thousand mariners, who had ‘ been consumed by the scurvy alone*?’ Yet so far was this author from mistaking the disease, that I have perused few who

* PURCHAS’S Pilgr. vol. iv. p. 1373, & seq.

have so well described it. If, then, in those early times, the infancy, I may call them, of the commerce and naval power of England, so many were carried off by that bane of sea-faring people, what must have been the destruction afterwards, upon the great augmentation of the fleet, and the opening of so many new ports to the trade of this country, whilst such little advancement was made in the nautical part of medicine !

BUT passing from these old dates to one within the remembrance of many here present, when it might have been expected that whatever tended to aggrandize the naval power of Great Britain, and to extend her commerce, would have received the highest improvement ; yet we shall find that, even at that late period, few measures had been taken to preserve the health of seamen, more than had been known to our

uninstructed ancestors. Of this assertion, the victorious but mournful expedition of Commodore ANSON affords too convincing a proof. It is well known that, soon after passing the Straits of Le Maire, the scurvy began to appear in his squadron; that, by the time the Centurion had advanced but a little way into the South Sea, forty-seven had died of it in that ship; and that there were few on board who had not, in some degree, been affected with the distemper, though they had not been quite eight months from England: that, in the ninth month, when standing for the island of Juan Fernandez, the Centurion lost double that number; and that the mortality went on at so great a rate (I still speak of the Commodore's ship) that, before they arrived there, she had buried two hundred; and at last could muster no more than two quarter-masters and six of the foremast-men, in a watch, capable of doing duty.

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This was the condition of one of the three ships which reached that island; the other two suffered in proportion.

NOR did the tragedy end here: for after a few months respite, the same fatal sickness broke out afresh, and made such havoc, that, before the Centurion (which now contained the whole surviving crew of the three ships) had got to the island of Tinian, there died sometimes eight or ten in a day; insomuch that, when they had been only two years on their voyage, they had lost a larger proportion than of four in five of their original number; and, by the account of the historian, all of them, after their entering the South Sea, of the scurvy. I say, by the account of the elegant writer of that voyage; for, as he neither was in the medical line himself, nor hath authenticated this part of his narrative by appealing to the surgeons of the ship, or to their

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journals,

journals, I should doubt that this was not strictly the case; but rather that, in producing this great mortality, a pestilential kind of distemper was joined to the scurvy, which, from the places where it most frequently occurs, hath been distinguished by the name of *the jail or hospital fever**. But whether the scurvy alone, or this fever combined with it, were the cause, it is not at present material to enquire; since both, arising from foul air and other sources of putrefaction, may now in a great measure be obviated by the various means fallen upon since Lord ANSON's expedition. For, in justice to that prudent as well as brave Commander, it must be observed, that the arrangements, preparatory to his voyage, were not made by himself; that his ship

* Dr. MEAD, who had seen the original observations of two of Commodore ANSON's surgeons, says, that the scurvy, at that time, was accompanied with *putrid fevers*, &c. See his *Treatise on the Scurvy*, p. 98, & seq.

was so deeply laden, as not, except in the calmest weather, to admit of opening the gun-ports for the benefit of air; and that nothing appears to have been neglected by him, for preserving the health of his men, that was then known and practised in the navy.

I SHOULD now proceed to enumerate the chief improvements made since that time, and which have enabled our ships to make so many successful circumnavigations, as in a manner to efface the impression of former disasters; but as I have mentioned the sickness most destructive to sailors, and against the ravages of which those preservatives have been mainly contrived, it may be proper briefly to explain its nature, and the rather as, excepting among mariners, it is little understood. First, then, I would observe, that the scurvy is not the disease which goes by
that

that name on shore. The distemper commonly, but erroneously, in this country, called the *scurvy*, belongs to a class of diseases totally different from what we are now treating of; and so far is the common received opinion, that *that there are few constitutions altogether free from a scorbutic taint*, from being true, that, unless among sailors and others circumstanced like them, more particularly with respect to those who use a salt and putrid diet, and especially if they live in foul air and uncleanness, I have reason to believe there are few disorders less frequent. This opinion I submitted to the judgment of the Society several years ago, and I have had no reason since to alter it. I then said, contrary to what was generally believed, but seemingly on the best grounds, that the sea-air was never the cause of the scurvy, since, on board a ship on the longest voyages, cleanliness, ventilation, and fresh provisions, would
 preserve

preserve from it; and that upon a sea-coast, free from marshes, the inhabitants were not liable to that indisposition, though frequently breathing the air from the sea *. I concluded with joining in sentiment with those, who ascribed the scurvy to a septic resolution, that is, a beginning corruption of the whole habit, similar to that of every animal substance when deprived of life. †. This account seemed to be sufficiently verified by the examination of the symptoms in the scorbutic sick, and by the appearances in their bodies after death ‡. On that occasion I remarked, that salted meats, after some time, become in reality putrid, though they may continue long palatable by

* Diseases of the Army, part i. ch. 2. Append Pap. 7.

† Ibid.

‡ WOODALL's Surgeon's Mate, p. 163. POU-PART. Mem. de l' Acad. R. des Sc. A. 1699. PETIT, Mal. des Os, tom. ii. p. 446. MEAD on the Scurvy, p. 104.

means of the salt ; and that common salt, supposed to be one of the strongest preservatives from corruption, is at best but an indifferent one, even in a large quantity ; and in a small one, such as we use at table with fresh meats, or swallow in meats that have been salted, so far from impeding putrefaction, it rather promotes that process in the body.

THIS position concerning the putrefying quality of sea-salt, in certain proportions, hath been since confirmed by the experiments of the late Mr. CANTON, Fellow of this Society, in a Paper on the *Cause of the Luminous Appearance of Sea-Water**.

IT hath been alleged, that the scurvy is much owing to the coldness of the air, which checks perspiration, and on that account is the endemic distemper of the

* Phil. Transact. vol. lix. p. 446.

northern nations, particularly of those around the Baltic*. The fact is partly true, but, I doubt, not so the cause. In those regions, by the long and severe winters, the cattle, destitute of pasture, can barely live, and are therefore unfit for use; so that the people, for their provision during that season, are obliged to slaughter them by the end of autumn, and to salt them for above half the year. This putrid diet, then, on which they must so long subsist, and to which the inhabitants of the South are not reduced, seems to be the chief cause of the disease. And if we reflect that the lower people of the North have few or no greens nor fruit in the winter, little or no fermented liquors, and often live in damp, foul, and ill-aired houses, it is easy to conceive how they should become liable to the same disorder with seamen; whilst others,

* BARTHOLIN. Med. Danor. Domestic. p. 98.

of as high a latitude, but who live in a different manner, keep free from it. Thus we are informed, by LINNÆUS, that the Laplanders, one of the most hyperborean nations, know nothing of the scurvy*; for which no other reason can be assigned than their never eating putrid and salted meats, nor indeed salt with any thing, but their using all the winter the fresh flesh of their rein-deer.

THIS exemption of the Laplanders from the general distemper of the North, is the more observable, as they seldom taste vegetables, bread never, as we farther learn from that celebrated author. Yet, in the very provinces which border on Lapland, where they use bread, but scarcely any other vegetable, and eat salted meats, they are as much troubled with the scurvy as in

* LINNÆI *Flora Lapponica*, p. 8, 9.

any other country *. But let us incidentally remark, that the late improvements in agriculture, gardening, and in the other arts of life, by extending their influence to the remotest parts of Europe, and to the lowest people, begin sensibly to lessen the frequency of that complaint, even in those climates that have been once the most afflicted with it.

It hath also been asserted, that men living on shore will be affected with the scurvy, though they have never been confined to salted meats ; but of this I have known no instance, except in those who breathed a marshy air, or what was otherwise putrid, and who wanted exercise, fruits, and the common herbs : under such circumstances, it must be owned that the humours

* LINNÆUS, in several parts of his work, confirms what is here said of salted meats, as one of the chief causes of the scurvy. See *Amœnitat. Acad.* vol. v. p. 6. & seq. p. 42.

will corrupt in the same manner, though not in the same degree, with those of seamen. Thus, in the late war, when Sisinghurst Castle in Kent was filled with French prisoners, the scurvy broke out among them, notwithstanding they had never been served with salted victuals in England, but had daily had an allowance of fresh meat, and of bread in proportion, though without greens or other vegetables. The country surgeon who attended them, and from whom I received this information, having formerly been employed in the navy, was the better able to judge of the disorder, and to cure it. Besides the deficiency of herbs, he observed that the wards were foul and crowded, the house damp (from a moat that surrounded it), and that the bounds allotted for taking the air were so small, and in wet weather so flougy, that the men seldom cared to go out. He added, that a representation having been made, he

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had

had been empowered to furnish the prisoners with roots and greens for boiling in their soup, and to quarter the sick in a neighbouring village, in a dry situation, with liberty to go out for air and exercise ; and that by these means they had all quickly recovered. It is probable, that the scurvy sooner appeared among these strangers, from their having been taken at sea, and being, from their diet, more disposed to the disease. My informer farther acquainted me, that, in the lower and wetter parts of that county, where some of his practice lay, he had now and then met with slihter cases of the scurvy among the common people ; such, he said, as lived the whole winter on salted bacon, without fermented liquors, greens, or fruit, a few apples excepted ; but he remarked, that, in the winters following a plentiful growth of apples, these peasants were manifestly less liable to the complaint.

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I HAVE

I HAVE dwelt the longer on this part of my subject, as I look upon the knowledge of the nature and cause of the scurvy to be an essential step towards improving the means of prevention and cure. And I am persuaded, after mature reflection, and the opportunities I have had of conversing with those, who to much sagacity had joined no small experience in nautical practice, that, upon an examination of the several articles, which have either been of old approved, or have of late been introduced into the navy, it will be found, that, though these means may vary in form, and in their mode of operating; yet that they all some way contribute towards preventing or correcting *putrefaction*, whether of the air in the closer parts of a ship, of the meats, of the water, of the clothes and bedding, or of the body itself. And, if in this inquiry (which may be made by the way, whilst we take a review of the principal articles of provision,

and

and other methods used by Captain Cook to guard against the scurvy), I say, if in this inquiry it shall appear, that the notion of a septic or putrid origin, is not without foundation, it will be no small encouragement to proceed on that principle, in order farther to improve this important branch of medicine.

CAPTAIN COOK begins his list of his preservative stores with *malt*: ‘Of this,’ he says, ‘was made *sweet wort*, and given not only to those men who had manifest symptoms of the scurvy, but to such also as were judged to be most liable to it.’ Dr. MACBRIDE, who first suggested this preparation, was led (as he observes) to the discovery by some experiments that had been laid before this Society, by which it appeared that the air produced by alimentary fermentation was endowed with a

power of correcting putrefaction *. The fact he confirmed by numerous trials ; and, finding this fluid to be the *fixed air*, he justly concluded, that whatever substance, proper for food, abounded with it, and which could be conveniently carried to sea, would make one of the surest remedies against the scurvy ; which he then considered as a *putrid disease*, and, as such, to be prevented or cured by that powerful kind of antiseptic †. Beer, for instance, had always been esteemed one of the best antiscorbutics ; but, as that derived all its *fixed air* from the malt of which it was made, he inferred that malt itself was preferable in long voyages, as it took up less room than the brewed liquor, and would keep longer sound. Experience hath since verified this

* Append. to my *Observations on the Diseases of the Army*.

* MACBRIDE'S Exper. Ess. *passim*.

ingenious

ingenious theory; and the malt hath now gained so much credit in the navy, that there only wanted so long, so healthful, and so celebrated a voyage as this, to rank it among the most indispensable articles of provision. For though Captain COOK remarks, that ‘ a proper attention to other
 ‘ things must be joined, and that he is not
 ‘ altogether of opinion that the wort will
 ‘ be able to cure the scurvy, in an advanced
 ‘ state, at sea; yet he is persuaded that it
 ‘ is sufficient to prevent that distemper
 ‘ from making any great progress, for a
 ‘ considerable time;’ and therefore he doth not hesitate to pronounce it ‘ one of the
 ‘ best antiscorbutic medicines yet found
 ‘ out*.’

THIS

* Having been favoured with a sight of the medical journal of Mr. PATTEN, surgeon to the Resolution, I read the following passage in it, not a little strengthening the above testimony: ‘ I have found the wort
 ‘ of the utmost service, in all scorbutic cases, during

THIS salutary *gas* (or *fixed air*) is contained, more or less, in all fermentable liquors, and begins to oppose putrefaction, as soon as the working or intestine motion commences.

IN wine, it abounds; and perhaps no vegetable substance is more replete with it than the juice of the grape. If we join the grateful taste of wine, we must rank it the first in the list of antiscorbutic liquors. Cyder is likewise excellent, with other vinous productions from fruit; as also the

‘ the voyage. As many took it by way of prevention, few cases occurred where it had a fair trial; but these, however, I flatter myself, will be sufficient to convince every impartial person, that it is the best remedy hitherto found out for the cure of the sea-scurvy: and I am well convinced, from what I have seen the *wort* perform, and from its mode of operation, that, if aided by *portable soup*, *sour krout*, *sugar*, *sago*, and *courants*, the scurvy, that maritime pestilence, will seldom or never make its alarming appearance among a ship’s crew, on the longest voyages; proper care with regard to cleanliness and provisions being observed.’

various

various kinds of beer. It hath been a constant observation, that, in long cruises or distant voyages, the scurvy is never seen whilst the small-beer holds out at a full allowance ; but that, when it is all expended, the distemper soon prevails. It were therefore to be wished, that this most wholesome beverage could be renewed at sea ; but our ships afford not sufficient convenience. The Russians, however, make a shift to prepare on board, as well as at land, something of a middle quality between wort and small-beer, in the following manner : They take ground malt and rye-meal, in a certain proportion, which they knead into small loaves, and bake in the oven. These they occasionally infuse in a proper quantity of warm water, which begins so soon to ferment, that, in the space of twenty-four hours, their brewage is completed, in the production of a small, brisk, and acidulous liquor, they call *quas*,

palatable to themselves, and not disagreeable to the taste of strangers. The late Dr. MOUNSEY, fellow of this Society, who had lived long in Russia, and had been *Archiatre* under two successive sovereigns, acquainted me, that the *quas* was the common and salutary drink both of the fleets and armies of that empire, and that it was particularly good against the scurvy. He added, that, happening to be at Moscow when he perused my *Observations on the Jail and Hospital Fever*, then lately published*, he had been induced to compare what he read in that treatise with what he should see in the several prisons of that large city. But, to his surprise, after visiting them all, and finding them full of malefactors (for the late Empress at that time suffered none who were convicted of capi-

* That treatise was first published by itself, and afterwards incorporated with the *Observations on the Diseases of the Army*.

tal crimes to be put to death), he could discover no fever among them, nor learn that any acute distemper, peculiar to jails, had ever been known there. He observed, that some of these places of confinement had a yard, into which the prisoners were allowed to come for the air; but that there were others without that advantage, yet not sickly. So that he could assign no other reason for the healthful condition of these men than the kind of diet they used, which was the same with that of the common people of the country; who, not being able to purchase flesh-meat, live mostly on rye-bread (the most acedent of any bread), and drink *quas*. He concluded with saying, that, upon his return to St. Petersburg, he had made the same enquiry there, and with the same result.

THUS far Dr. MOUNSEY; from whose account it would seem, that the rye-meal
 assisted

assisted both in quickening the fermentation and adding more fixed air, since the malt alone could not so readily produce so tart and brisk a liquor. And there is little doubt, but that, whenever the other grains can be brought to a proper degree of fermentation, they will, more or less, in the same way, become useful. That oats will, I am satisfied, from what I have been told by one of the intelligent friends of Captain Cook. This gentleman being on a cruise in a large ship *, in the beginning of the late war, and the scurvy breaking out among his crew, he bethought himself of a kind of food he had seen used in some parts of the country, as the most proper on that occasion. Some oat-meal is put into a wooden vessel, hot water is poured upon it, and the infusion continues until the liquor begins to taste sourish, that is, till a fermentation comes on, which, in a place

* The Effex, a seventy gun ship.

moderately

moderately warm, may be in the space of two days. The water is then poured off from the grounds, and boiled down to the consistence of a jelly*. This he ordered to be made and dealt out in messes, being first sweetened with sugar, and seasoned with some prize French wine, which, though turned sour, yet improved the taste, and made this aliment not less palatable than medicinal.

HE assured me, that, upon this diet chiefly, and by abstaining from salted meats, his *scorbutic* sick had quite recovered on board; and not in that voyage only, but, by the same means, in his subsequent cruizes during the war, without his being obliged to send one of them on shore because they could not get well at sea. Yet oat-meal unfermented, like barley unmalted, hath no sensible effect in curing the

* This rural food, in the North, is called *sooins*.

scurvy;

scurvy ; as if the *fixed air*, which is incorporated with these grains, could mix with the chyle which they produce, enter the lacteals with it, and make part of the nourishment of the body, without manifesting any elastic or antiseptic quality, when not loosened by a previous fermentation.

BEFORE the power of the *fixed air*, in subduing putrefaction, was known, the efficacy of fruits, greens, and fermented liquors, was commonly ascribed to the acid in their composition ; and we have still reason to believe that the acid concurs in producing that effect. If it be alleged that mineral acids, which contain little or no *fixed air*, have been used in the scurvy with little success ; I would answer, that I doubt that, in those trials, they have never been sufficiently diluted ; for it is easy to conceive, that, in the small quantity of water the elixir of vitriol, for instance, is com-
monly

monly given, that austere acid can scarcely get beyond the first passages ; considering the delicate sensibility of the mouths of the lacteals, which must force them to contract, and exclude so pungent a liquor. It were therefore a proper experiment to be made, in a deficiency of malt, or when that grain shall happen to be spoiled by keeping *, to use distilled water, acidulated with the spirit of sea-salt, in the proportion of only ten drops to a quart ; or with the weak spirit of vitriol, thirteen drops to the same measure † ; and to give to those that are threatened with the scurvy at least three quarts of

* Captain Cook told me, that the malt held out sufficiently good for the two first years ; but that in the third, having lost much of its taste, he doubted whether it retained any of its virtues. Mr. PATTEN, however, observed, that, though the malt at that time was sensibly decayed, yet nevertheless he had still found it useful, when he employed a larger proportion of it to make the infusion.

† In these proportions I found the water taste just acidulous and pleasant.

this

this liquor daily, to be consumed as they shall think proper.

BUT if the *fixed air* and acids are such preservatives against the scurvy, why should Captain COOK make so little account of the *rob* of lemons and of oranges (for so they have called the extracts or inspissated juices of those fruits) in treating that distemper? This, I found, was the reason: These preparations being only sent out upon trial, the surgeon of the ship was told, at a conjecture, how much he might give for a dose, but without strictly limiting it. The experiment was made with the quantity specified, but with so little advantage, that, judging it not adviseable to lose more time, he set about the cure with the wort alone, of the efficacy of which he was certain; whilst he reserved these *robs* for other purposes; more particularly for colds, when, to a large draught of warm water, with

with some spirits and sugar, he added a spoonful of one of them, and with this composition made a grateful sudorific that answered his intention. No wonder, then, if Captain Cook, not knowing how much to order of these concentrated juices for the scurvy, but seeing them fail as they were given at this time, should entertain no great opinion of their antiscorbutic virtue. It may be also proper to take notice, that, as they had been reduced to a small proportion of their bulk by evaporation upon fire, it is probable they were much weakened by that process, and that, with their aqueous parts, they had lost not a little of their aërial, on which so much of their antiseptic power depended. If, therefore, a farther trial of these excellent fruits were to be made, it would seem more adviseable to send to sea the purified juices entire in casks; agreeably to a proposal which I find hath been presented to the Admiralty, some

years ago, by an ingenious and experienced surgeon of the navy. For, in truth, the testimonies in favour of the salutary qualities of these acids are so numerous, and so strong, that I should look upon some failures, even in cases where their want of success cannot so well be accounted for as in this voyage, as not a sufficient reason for striking them out of the list of the most powerful preservatives against the consuming malady of sailors.

It may be observed, that Captain Cook says not more in praise of vinegar than of the *robs* ; yet I would not thence infer that he made no account of that acid ; but only that, as he happened in this voyage to be sparingly provided with it, and yet did well, he could not consider a large store of vinegar to be so material an article of provision as was commonly imagined. And, though he supplied its place in the messes
of

of the men with the acid of the *sour krout*, and trusted chiefly to fire for purifying his decks, yet it is to be hoped that future navigators will not therefore omit it. Vinegar will serve at least for a wholesome variety in the seasoning of salted meats, and may be sometimes successfully used as a medicine, especially in the aspersions of the berths of the sick. It is observable, that, though the smell be little grateful to a person in health, yet it is often agreeable to those who are sick, at least to such as are confined to a foul and crowded ward. There the physician himself will smell to vinegar, as much for pleasure, as for guarding against infection.

Now the wort and the acid juices were only dispensed as medicines; but the next article was of more extensive use. This was the *sour krout* (sour cabbage), a food of universal request in Germany. The

N

acidity

acidity is acquired by its spontaneous fermentation, and it was that very taste which made it the more acceptable to all who ate it. To its farther commendation we may add, that it held out good to the last of the voyage.

IT may seem strange, that though cabbage hath had so high encomiums bestowed upon it by the ancients (witness what CATO the elder and PLINY the naturalist say on the subject), and hath had the sanction of the experience of nations for ages, it should yet be disapproved of by some of the distinguished medical writers of our times. One finds it yield a rank smell in decoction, which he confounds with that of putrefaction. Another analyzes it, and discovers so much gross air in the composition, as to render it indigestible; yet this flatulence, so much decried, must now be acknowledged to be the *fixed air*, which
makes

makes the cabbage so wholesome when fermented. Nay it hath been traduced by one of the most celebrated physicians of our age, as partaking of a poisonous nature : nor much better founded was that notion of the same learned professor, that, cabbage being an alcalescent plant, and therefore disposing to putrefaction, it could never be used in the scurvy, excepting when the disease proceeded from an acid. But the experiments, which I formerly laid before the Society, evinced this vegetable, with the rest of the supposed alcalescents, to be really acescent ; and proved that the scurvy is never owing to acidity, but, much otherwise, to a species of putrefaction ; that very cause, of which the ill-grounded class of alcalescents was supposed to be a promoter*.

* See this remark more at large, in my *Observations on the Diseases of the Army*, App. Pap. 7.

AMONG other of the late improvements of the naval stores, we have heard much of the *portable soup*, and accordingly we find that Captain COOK hath not a little availed himself of it in his voyage. This concentrated broth, being freed from all fat, and having by long boiling evaporated the most putrescent parts of the meat, is reduced to the consistence of a glue, which in effect it is, and will, like other glues, in a dry place, keep sound for years together. It hath been said, that broths turn sour on keeping, though made without any vegetable*. Now, whether any real acid can be thus formed or not, I incline at least to believe, that the gelatinous parts of animal substances, such as compose these cakes, are not of a nature much disposed to putrefy. But, however that may be, since

* ‘ La seule matiere qui s’agrisse dans le sang est la
‘ matiere gelatineuse, &c.’ SENAC, Structure du
Cœur, l. iii. ch. iv. § 5.

Captain COOK observes, that this soup was the means of making his people eat a greater quantity of greens than they would have done otherwise, so far we must allow it to have been virtually antiseptic.

So much for those articles that have of late been supplied to all the King's ships on long voyages, and in which, therefore, our worthy brother claims no other merit than the prudent dispensation of them ; but what follows, being regulations either wholly new, or improved hints from some of his experienced friends, we may justly appropriate them to himself.

FIRST, then, he put his people at three watches, instead of two, which last is the general practice at sea ; that is, he divided the whole crew into three companies, and, by ordering each company upon the watch by turns, four hours at a time, every man

had eight hours free, for four of duty : whereas, at watch and watch, the half of the men being on duty at once, with returns of it every four hours, they can have but broken sleep, and, when exposed to wet, they have not time to get dry before they lie down. When the service requires them, such hardships must be endured ; but when there is no pressing call, ought not a mariner to be refreshed with as much uninterrupted rest as a common labourer ?

I AM well informed, that an officer distinguishes himself in nothing more than in preserving his men from wet, and the other injuries of the weather. These were most essential points with this humane Commander. In the torrid zone, he shaded his people from the scorching sun by an awning over his deck ; and, in his course under the antarctic circle, he had a coat provided for each man, of a substantial wool-
len

len stuff, with the addition of a hood for covering their heads. This garb (which the sailors called their *Magellan jacket*) they occasionally wore, and found it most comfortable for working in rain and snow, and among the broken ice in the high latitudes of the South.

LET us proceed to another article, one of the most material, the care to guard against putrefaction, by keeping clean the persons, the clothes, the bedding, and berths of the sailors. The Captain acquainted me, that regularly, one morning in the week, he passed his ship's company in review, and saw that every man had changed his linen, and was in other points as clean and neat as circumstances would permit. It is well known how much *cleanliness* is conducive to health, but it is not so obvious how much it also tends to

regularity and other virtues. That diligent officer was persuaded, that such men as he could induce to be more cleanly than they were disposed to be of themselves, became at the same time more sober, more orderly, and more attentive to their duty. It must be acknowledged that a seaman has but indifferent means to keep himself clean, had he the greatest inclination to do it; for I have not heard that commanders of ships have yet availed themselves of the *still* for providing fresh water for washing; and it is well known that sea-water doth not mix with soap, and that linen wet with brine never thoroughly dries. But for Captain COOK, the frequent opportunities he had of taking in water among the islands of the South-Sea, enabled him in that tract to dispense to his ship's company some fresh water for every use; and when he navigated in the high latitudes of the
southern

southern oceans, he still more abundantly provided them with it, as you will find by the sequel of this discourse.

OF the hammocks and bedding I need say little, as all officers are now sensible, how much it concerns the health of their people to have this part of a ship's furniture kept dry and well aired; as by the breath and perspiration of so many men, every thing below, even in the space of twenty-four hours, is apt to contract an offensive moisture. But Captain Cook was not satisfied with ordering upon deck the hammocks and bedding every day that was fair (the common practice), but took care that every bundle should be unlash'd, and so spread out, that every part of it might be expos'd to the air,

HIS next concern was to see to the purity of the ship itself, without which attention

tention all the rest would have profited little. I shall not however detain you with his orders about washing and scraping the decks, as I do not understand that in this kind of cleansing he excelled others; but since our author has laid so great a stress upon *fire*, as a purifier, I shall endeavour to explain his way of using it, more fully than he has done in his Paper. Some wood, and that not sparingly, being put into a proper stove or grate, was lighted, and carried successively to every part below deck. Wherever fire is, the air nearest to it being heated becomes specifically lighter, and by being lighter rises, and passes through the hatchways into the atmosphere. The vacant space is filled with the cold air around, and that being heated in its turn, in like manner ascends, and is replaced by other air as before. Thus, by continuing the fire for some time, in any of the lower apartments, the foul
 air

air is in a good measure driven out, and the fresh admitted. This is not all: I apprehend that the acid steams of the wood, in burning, act here as an antiseptic, and correct the corrupted air that remains.

AN officer of distinguished rank, another of Captain COOK's experienced friends, mentioned to me a common and just observation in the fleet, which was, that all the old twenty-gun ships were remarkably less sickly than those of the same size of a modern construction. This, he said, was a circumstance he could not otherwise account for, than by the former having their *galley** in the fore-part of the *orlop*†, the chimney vented so ill, that it was sure to fill every part with smoke whenever the wind was a-stern. This was a nuisance for the time, but, as he thought, abun-

* Their fire-place or kitchen.

† The deck immediately above the hold.

dantly

dantly compensated by the extraordinary good health of the several crews. Possibly these fire-places were also beneficial, by drying and ventilating the lower decks, more when they were below, than they can do now that they are placed under the fore-castle upon the upper deck.

BUT the most obvious use of the portable fires was their drying up the moisture, and especially in those places where there was the least circulation of air. This humidity, composed of the breath and perspirable matter of a multitude of men, and often of animals (kept for a live-stock), and of the steams of the bilge water from the well, where the corruption is the greatest; this putrid moisture, I say, being one of the main causes of the scurvy, was therefore more particularly attended to, in order to its removal. The fires were the powerful instrument for that purpose; and whilst
they

they burned, some men were employed in rubbing hard, with canvass or oakhum, every part of the inside of the ship that was damp and accessible. But the advantage of fire appears no where so manifest as in cleansing the well ; for this being in the lowest part of the hold, the whole leakage runs into it, whether of the ship itself, or of the casks of spoilt meats or corrupted water. The mephitic vapours from this sink alone have often been the cause of instantaneous death to those who have unwarily approached to clean it ; and not to one only, but to several successively, when they have gone down to succour their unfortunate companions. Yet this very place hath not only been rendered safe but sweet, by means of an iron pot filled with fire and let down to burn in it.

WHEN, from the circumstances of the weather, this salutary operation could not
take

take place, the ship was fumigated with gun-powder, as described in Captain COOK's Paper; though that smoke could have little or no effect in drying, but only in remedying the corruption of the air, by means of the acid spirits from the sulphur and nitre, aided perhaps by some species of an aërial fluid, then disengaged from the fuel, to counteract putrefaction. But as these purifications by gun-powder, as well as by burning tar and other resinous substances, are sufficiently known, I shall not insist longer on them here.

AMONG the several means of sweetening or renewing the air, we should expect to hear of Dr. HALES's ventilator. I must confess it was my expectation, and therefore, persuaded as I was of the excellence of the invention, it was not without much regret that I saw so good an opportunity lost, of giving the same favourable impression

sion of it to the Public. If a degree of success, exceeding our most sanguine hopes, is not sufficient for justifying the omission of a measure, deemed one of the most essential for attaining an end, I would plead in favour of our worthy brother, that by a humiliating fatality, so often accompanying the most useful discoveries, the credit of this ventilator is yet far from being established in the navy. What wonder then, if Captain Cook, being so much otherwise taken up, should not have had time to examine it, and therefore avoided the encumbering his ship with an apparatus he had possibly never seen used, and of which he had at best received but a doubtful character? Nor was he altogether unprovided with a machine for ventilation. He had the *wind-sails*, though he hath not mentioned them in his Paper; and he told me that he had found them at times very serviceable, and particularly between the
Tropics.

Tropics. They have the merit of taking up little room, they require no labour in working, and the contrivance is so simple that they can fail in no hands. But their powers are small in comparison with those of Dr. HALE'S ventilator : they cannot be put up in hard gales of wind, and are of no efficacy in dead calms, when a refreshment of the air is most wanted. Should there be any objection to the having them both ?

SUCH were the measures taken by our sagacious Navigator for procuring a purity of air. It remains only to see in what manner he supplied pure water ; another article of so great moment, that the thirsty voyager, upon his salt and putrid diet, with a short allowance of that element, and that in a corrupted state, must account a plentiful provision of fresh water to be indeed *the best of things*.

CAPTAIN

CAPTAIN COOK was not without an apparatus for distilling sea-water, and though he could not obtain nearly so much as was expected from the invention, yet he sometimes availed himself of it; but for the most of his voyage he was otherwise provided. Within the southern tropic, in the Pacific Ocean, he found so many islands, and those so well stored with springs, that, as I have hinted before, he seldom was without a sufficiency of water for every useful purpose. Yet, not satisfied with plenty, he would have the purest; and therefore, whenever an opportunity offered, he emptied what he had taken in only a few days before, and filled his casks anew. But was he not above four months in his passage from the Cape of Good Hope to New Zealand, in the frozen zone of the South, without once seeing land? and did he not actually complete his courses in the other high latitudes, without the

benefit of a single fountain? Here was indeed *a wonder of the deep!* I may call it the *romance of his voyage!* Those very shoals, fields, and floating mountains of ice, among which he steered his perilous course, and which presented such terrifying prospects of destruction; those, I say, were the very means of his support, by supplying him abundantly with what he most wanted. It had been said that those vast masses of ice, called *islands* or *mountains*, melted into fresh water; though CRANTZ, the relator of that paradox, did not imagine they originated from the sea, but that they were first formed in the great rivers of the North, and, being carried down into the ocean, were afterwards increased to that amazing height by the snow that fell upon them*. But that all frozen sea-water would thaw into fresh,

* Hist. of Greenland, b. i. ch. ii. § 11, 12.

had either never been asserted, or had met with little credit. This is certain, that Captain COOK expected no such transmutation, and therefore was agreeably surprised to find he had one difficulty less to encounter, that of preserving the health of his men so long on salt and putrid provisions, with a scanty allowance of corrupted water, or what he could procure by distillation. The melted ice of the sea was not only fresh, but soft; and so wholesome, as to shew the fallacy of human reason unsupported by experiments. An ancient, of great authority, had assigned, from theory, bad qualities to melted snow; and, from that period to the present times, this prejudice, extending to ice, had not been quite removed.

IN this circumnavigation, amidst flects and falls of snow, fogs, and much moist weather, the Resolution enjoyed nearly the

same state of health she had done in the temperate and torrid zones. It appears only from the journal of the surgeon, that, towards the end of the several courses, some of the crew began to complain of the scurvy; but the disease made little progress, excepting in one who had become early an invalid from another cause. The other disorders were likewise neither numerous nor fatal, such as colds in various forms, slight diarrhœas, and intermittents that readily yielded to the Bark. There were also some continued fevers, but which, by timely care, never rose to an alarming height. Much commendation is therefore due to the attention and abilities of Mr. PATTEN, the surgeon of the Resolution, for having so well seconded his captain in the discharge of his duty. For it must be allowed, that, in despite of the best regulations and the best provisions, there will always be, among a numerous crew, during a long voyage,

some

some casualties more or less productive of sickness ; and, unless there be an intelligent medical assistant on board, many, under the wisest commander, will perish, that otherwise might have been saved.

THESE, GENTLEMEN, are the reflections I had to lay before you on this interesting subject ; and, if I have encroached on your time, you will recollect that much of my discourse hath been employed in explaining some things but just mentioned by Captain COOK, and in adding other materials, which I had procured partly in conversation with himself, and partly, after his departure, with those intelligent friends he alludes to in his Paper. This was my plan ; which, as I have now executed, you will please to return your thanks to those gentlemen, who, on your account, so cheerfully communicated to me their observations.

As to your acknowledgments to Captain COOK, and your high opinion of his deserts, you will best testify them by the honourable distinction suggested by your Council, in presenting him with this Medal: for I need not gather your suffrages, since the attention, with which you have favoured me, hath abundantly expressed your approbation. My satisfaction, therefore, had been complete, had he himself been present to receive the honours you now confer upon him. But you are apprised that our brave and indefatigable Brother is at this instant far removed from us, anticipating, I may say, your wonted request on these occasions, by continuing his labours for the advancement of Natural Knowledge, and for the honour of this Society; as you may be assured, that the object of his new enterprize is not less great, perhaps still greater, than either of the former.

ALLOW

ALLOW me then, GENTLEMEN, to deliver this Medal, with his unperishing name engraven upon it, into the hands of one who will be happy to receive that trust, and to know that this respectable Body never more cordially nor more meritoriously bestowed that faithful symbol of their esteem and affection. For if Rome decreed the *Civic Crown* to him who saved the life of a single citizen, what wreaths are due to that Man, who, having himself saved many, perpetuates in your Transactions the means by which Britain may now, on the most distant voyages, preserve numbers of her intrepid sons, her *Mariners*; who, braving every danger, have so liberally contributed to the fame, to the opulence, and to the maritime empire, of their country*!

* Here followed Captain Cook's Paper, which was presented to the Society, and is inserted in part ii. vol. lxvi. of the Philosophical Transactions; but, as

the substance of that publication is now contained in the last pages of Captain Cook's Voyage, it was judged unnecessary to repeat it here. The only material circumstance of Captain Cook's communication to the Society, omitted in his Journal, is the following extract of a letter which he wrote to the President, just before his late embarkation, dated Plymouth Sound, July 7, 1776; and is as follows :

‘ I entirely agree with you, that the dearth of the
 ‘ rob of lemons and of oranges will hinder them from
 ‘ being furnished in large quantities ; but I do not
 ‘ think this so necessary ; for, though they may assist
 ‘ other things, I have no great opinion of them alone.
 ‘ Nor have I a higher opinion of vinegar : my people
 ‘ had it very sparingly during the late voyage, and,
 ‘ towards the latter part, none at all ; and yet we
 ‘ experienced no ill effects from the want of it. The
 ‘ custom of washing the inside of the ship with vine-
 ‘ gar, I seldom observed ; thinking that fire and
 ‘ smoke answered the purpose much better.’

A
D I S C O U R S E
ON THE
INVENTION AND IMPROVEMENTS
OF THE
REFLECTING TELESCOPE;

DELIVERED AT THE
Anniversary Meeting of the ROYAL SOCIETY,
November 30, 1777.

By Sir JOHN PRINGLE, Bart. PRESIDENT.

PUBLISHED AT THEIR REQUEST.

A
D I S C O U R S E
ON THE
INVENTION AND IMPROVEMENTS
OF THE
REFLECTING TELESCOPE.

GENTLEMEN,

IT was with equal truth and modesty observed by our most worthy Brother, the Reverend Dr. BRADLEY, in his celebrated Paper concerning the apparent motion of the fixed stars, and the causes of that deception, ' that the great exactness with which instruments are now constructed hath enabled

‘ bled the astronomers of the present age to
 ‘ discover several changes in the position of
 ‘ the heavenly bodies, which, by reason of
 ‘ their smallness, had escaped the notice of
 ‘ their predecessors *.’ And indeed it was
 upon this liberal principle, the embracing
 of every assistance which could be advantageous to their institution, that this Society, from their foundation to this day, have cherished the mechanical arts; nay, have often associated those artists that had invented or perfected instruments eminently conducive to the advancement of Natural Knowledge.

It is a merit of this kind, I would say a signal mechanical improvement, which your Council have thought proper at this time to distinguish; and they have accordingly empowered me to announce to you, on this day of your annual solemnity, that

* Phil. Transf. vol. xlv.

they

they have adjudged the Prize Medal, founded on the benefaction of Sir GODFREY COPLEY, Baronet, to Mr. JOHN MUDGE of Plymouth, Fellow of this Society, on account of his valuable Paper, ‘ containing directions for making the best ‘ composition for the metals of reflecting ‘ telescopes, together with a description of ‘ the process for grinding, polishing, and ‘ giving the great speculum the true parabolic form*.’ Nor do they doubt (conscious as they are of their zeal for the honour of the Society, and of their attention to their duty) of obtaining your wonted approbation, when they shall have laid before you the reasons which moved them to put this mark of distinction upon that communication, amidst a number of others very deserving of praise †.

* Phil. Transf. vol. lxvii. part i.

† The encouragement of *experimental* improvements, it may be observed, was the main object of the institution of Sir GODFREY COPLEY’s Medal.

BUT,

BUT, before I enter upon these considerations, allow me briefly to recal to your memory some particulars concerning the invention of reflecting telescopes, the subsequent improvements of these instruments, and the state in which Mr. MUDGE found them, when he first set about working them to a greater perfection, than was attainable either by the methods which the artificers thought proper to divulge, or the directions that had been given by learned writers on that subject. Thus you will have under your view sufficient materials to judge of the merits of his performance, and of the equity of your Council in decreeing these honours to him.

‘ It must be acknowledged,’ says Dr. SMITH in his Complete System of Optics, ‘ that Mr. JAMES GREGORY of Aberdeen ‘ was the first inventor of the reflecting ‘ telescope ; but his construction is quite ‘ different

‘ different from Sir ISAAC NEWTON’s,
 ‘ and not nearly so advantageous*.’

BUT, with much deference to so respectable an author, and with all regard to the fame of GREGORY, let us not forget to do justice to MERSENNUS, by acknowledging him to be the man who is entitled to the credit of having entertained the *first* thought of a reflector. A telescope with *specula* he certainly proposed to the celebrated DESCARTES, many years before GREGORY’s invention; though indeed in a manner so very unsatisfactory, that DESCARTES, who had given particular attention to the improvement of the telescope, was so far from approving the proposal, that he endeavoured to convince MERSENNUS of its fallacy†. Dr. SMITH,
 it

* Remarks upon Art. xxiv.

† Lettres de DESCARTES, tom. ii. printed at Paris in 1657, lett. 29. and 32. See this point discussed by
 two

it appears, had never perused the two letters of DESCARTES to MERSENNUS which briefly touch on that subject.

AGAIN, as to his assertion, ‘ that GREGORY’s construction was not nearly so advantageous as NEWTON’s,’ it may be accounted for from his having set it down early in the composition of his work, and forgetting to qualify it afterwards, when, before the publication, he had received pretty sure information to the contrary. Or perhaps he was influenced by the example of Dr. BRADLEY, who had been a most successful observer, and yet had always preferred the *Newtonian* telescope to the other. But if long experience is allowed to be the final arbiter in such matters, we must adjudge the superiority to the latter, as that is now, and has been for several years past, the only instrument of the kind in request.

two learned and candid authors, M. LE ROI in the *Encyclopedie*, under the article *Telescope*; and M. MONTUCLA in *Hist. des Mathem.* tom. ii. p. 643.

GREGORY,

GREGORY, a young man of an uncommon genius, was led to the invention, in seeking to correct two imperfections of the common telescope; the first was, its too great length, which made it less manageable; the second, the incorrectness of the image. Mathematicians had demonstrated, that a pencil of rays could not be collected in a single point by a spherical lens; and also, that the image transmitted by such a lens would be in some degree incurvated. These inconveniences, he believed, would be obviated, by substituting for the object glass a metallic speculum, of a parabolic figure, to receive the image, and to reflect it towards a small speculum of the same metal: this again was to return the image to an eye glass placed behind the great speculum, which, for that purpose, was to be perforated in its centre. This construction he published in 1663, in his *Optica Promota*, a work which in every respect doth

honour to the author. But as GREGORY, as he himself declares, was endowed with no mechanical dexterity, nor could find any workman capable of realizing his invention; after some fruitless attempts in that way, he was obliged to give up the pursuit: and, probably, had not some new discoveries been made in light and colours, a reflecting telescope would never more have been thought of, considering the difficulty of the execution, and the small advantages that could accrue from it, deducible from the principles of optics that were then known.

BUT NEWTON, whose happy genius for experimental knowledge was equal to that for geometry, and who to these talents, in a supreme degree, joined patience and mechanical abilities; NEWTON, I say, thus accomplished, happily interposed, and saved this noble invention from well-nigh perishing

ing in its infant state. He likewise, at an early period of life, had applied himself to the improvement of the telescope; but, imagining that GREGORY's *specula* were neither very necessary, nor likely to be executed, he began with prosecuting the views of DESCARTES, who aimed at making a more perfect image of an object, by grinding lenses, not to the figure of a sphere, but to that of one of the conic sections. Now, whilst he was thus employed, three years after GREGORY's publication, he happened to take to the examination of the colours formed by a prism; and having, by the means of that simple instrument, made the ever memorable discovery of the *different refrangibility of the rays of light*; he then perceived that the errors of telescopes, arising from that cause alone, were some hundred times greater than such as were occasioned by the spherical figure of lenses. This circumstance forced, as it

were, NEWTON to fall into GREGORY'S track, and to turn his thoughts to reflectors. ' The different refrangibility of the ' rays of light,' says he, in a letter to Mr. OLDENBURG, Secretary to this Society, dated in February 1672, ' made me take ' *reflections* into consideration, and finding ' them regular, so that the angle of reflection of all sorts of rays was equal to the ' angle of incidence, I understood that, by ' their mediation, optic instruments might ' be brought to any degree of perfection ' imaginable, provided a reflecting substance could be found, which would polish as finely as glass, and reflect as much light as glass transmits, and the art of communicating to it a parabolic figure be also obtained.—Amidst these thoughts, ' I was forced from Cambridge by the ' intervening plague; and it was more than ' two years before I proceeded farther *.'

* Phil. Transf. n. 80.

IT appears, then, that, if NEWTON was not the first inventor of the reflecting telescope, he was the main and effectual inventor. By the force of his admirable genius, he fell upon this new property of light, and thereby found that all lenses, of whatever figure, would be affected more or less with such prismatic aberrations of the rays, as would be an insuperable obstacle to the perfection of a dioptric telescope. Here was (if I may use the similitude) a disorder inherent in the constitution of this instrument, which NEWTON, like a wise physician, penetrated into, and, by understanding the nature of the disease, was led to the remedy ; one indeed that had been devised before, but for a different and a slighter ailment, and withal of such difficult composition, that the contriver of it himself had not been able to prepare it,

IT was towards the end of 1668, or in the beginning of the following year, when

NEWTON, being thus obliged to have recourse to reflectors, and not relying on any artificer for making his *specula*, set about the work himself, and, early in the year 1672, completed two small reflecting telescopes. In these he ground the great speculum into a spherical concave; not but that he approved of the parabolic form proposed by GREGORY, though he found himself unable to accomplish it. In a letter that accompanied one of these instruments, which he presented to the Society, he writes, ‘ that though he then despaired of performing that work (to wit, the parabolic figure of the great speculum) by geometrical rules, yet he doubted not but that the thing might in some measure be accomplished by mechanical devices*.’

Not less did the difficulty appear to find a metallic substance that would be of a

* Phil. Trans. n. 81.

proper hardness, have the fewest pores, and receive the smoothest polish : a difficulty, in truth, which he deemed almost insurmountable, when he considered that every irregularity in a reflecting surface would make the rays of light stray five or six times more out of their due course, than the like irregularities in a refracting one. In another letter, written soon after, he tells the Secretary, ‘ that he was very
 ‘ sensible that metal reflects less light than
 ‘ glass transmits ;—but as he had found
 ‘ some metalline substances to be more
 ‘ strongly reflective than others, to polish
 ‘ better, and to be freer from tarnishing
 ‘ than others, so he hoped that there might
 ‘ in time be found out some substances
 ‘ much freer from these inconveniences
 ‘ than any yet known*.’ Meanwhile here was, as I said, another stop ; and the more discouraging, as it was not, like the former,

* Phil. Transf. n. 82.

to be removed by ‘ mechanical devices,’ nor even by any chemical principle that had been discovered. That want could only be supplied by making repeated trials; nay, I may say, as it were, fortuitously. NEWTON therefore laboured till he found a composition that answered in some degree, and left it to those who should come after him to find a better. The industry of Mr. MUDGE has been aiding to that of Sir ISAAC NEWTON; and the happy assistant of that great man has been so candid as to acknowledge, that chance did save him much trouble, by furnishing him with a metallic mixture, which he had reason to believe was fitter for the purpose than any that had been used before, either published or concealed from the public.

NEWTON having, with his telescope, communicated to the Society a full and satisfactory account of its construction and performance,

performance, he received from your illustrious predecessors such thanks as were due to so curious and valuable a present. And HUYGENS, one of the greatest geniuses of the age, and himself a distinguished improver of the refractor, no sooner was informed by Mr. OLDENBURG of the discovery, than he wrote in answer, ‘ that it
 ‘ was an admirable telescope; and that Mr.
 ‘ NEWTON had well considered the advantage which a concave speculum had above
 ‘ convex glasses in collecting the parallel
 ‘ rays, which, according to his own calculation, was very great. Hence that Mr.
 ‘ NEWTON could give a far greater aperture to that speculum than to an object
 ‘ glass of the same distance of focus, and
 ‘ consequently much more magnify in his
 ‘ way than by an ordinary telescope. Besides, that by the reflector he avoided an
 ‘ inconvenience inseparable from object
 ‘ glasses, which was the obliquity of both
 ‘ their

‘ their surfaces, which vitiated the refraction
 ‘ of the rays that pass towards the sides of the
 ‘ glass, and did more hurt than men were
 ‘ aware of. Again, that by the mere re-
 ‘ flection of the metalline speculum there
 ‘ were not so many rays lost as in glasses,
 ‘ which reflected a considerable quantity by
 ‘ each of their surfaces, and besides inter-
 ‘ cepted many of them by the obscurity of
 ‘ their matter.—That the main business
 ‘ would be, to find a matter for this specu-
 ‘ lum, that would bear as good and even a
 ‘ polish as glass. Lastly, he believed that
 ‘ Mr. NEWTON had not been without
 ‘ considering the advantage which a para-
 ‘ bolic speculum would have above a spher-
 ‘ ical one in this construction; but had
 ‘ despaired, as he himself had done, of
 ‘ working other surfaces than spherical
 ‘ ones with due exactness*.’ HUYGENS
 was not satisfied with thus expressing to

* Phil. Trans. n. 81.

the Society his high approbation of the late invention, but drew up a favourable account of the new telescope, which he caused to be published in the *Journal des Sçavans*, of the year 1672, and by that channel it was soon known over Europe.

BUT how excellent soever the contrivance was, how well soever supported and announced to the public, yet, whether it was that the artists were deterred by the difficulty and labour of the work, or that the discoveries even of a NEWTON were not to be exempted from the general fatality attending great and useful inventions, *the making a slow and vexatious progress to the authors* ; the fact is, that, excepting an unsuccessful attempt which the Society made by employing an artificer to imitate the *Newtonian* construction, but upon a larger scale, and a disguised *Gregorian* telescope, set up by CASSEGRAIN abroad as a rival

rival to NEWTON's, and that in theory only (for it never was put in execution by the author*), no reflector was heard of for nearly half a century after. But, when that period was elapsed, a reflecting telescope was at last produced to the world of the *Newtonian* construction, which the venerable author, ere yet he had finished his much distinguished course, had the satisfaction to find executed in such a manner, as left no room to fear that the invention would longer continue in obscurity.

THIS memorable event was owing to the genius, dexterity, and application of a gentleman of this Society, Mr. HADLEY, the inventor of the reflecting quadrant, another most valuable instrument. The two telescopes which NEWTON had made were but six inches long, were held in the

* Compare MONTUCLA, Hist. de Mathem. tom. ii, p. 647.

hand for viewing objects, and in power were compared to a six feet refractor; whereas HADLEY's was above five feet long, was provided with a well-contrived apparatus for managing it, and equalled in performance the famous aërial telescope of HUYGENS, of 123 feet in length. Excepting as to the manner of making the *specula*, we have, in the Transactions of 1723, a complete description, with a figure, of this telescope, together with that of the machine for moving it; but, by a strange omission, NEWTON's name is not once mentioned in that Paper, so that any person, not acquainted with the history of the invention, and reading that account only, might be apt to conclude that HADLEY had been the sole contriver of it. But other Papers in the same volume, besides the Minutes of the Society, clearly shew that this worthy Member meant nothing less than

than to arrogate to himself any merit in this performance that properly belonged to NEWTON.

IT is known that the same celebrated artist, after finishing two telescopes of the *Newtonian* construction, accomplished a third in the *Gregorian* way; but, I should judge, less successfully, by Dr. SMITH's declaring so strongly in favour of the other. Mr. HADLEY was not less communicative than he was ingenious, being ever ready to impart his lights to others: in particular we are informed, ' that he spared no pains ' to instruct Mr. MOLYNEUX and the Reverend Dr. BRADLEY; and that when ' those gentlemen had made a sufficient ' proficiency in the art, being desirous that ' these telescopes should become more public, they liberally communicated to some ' of the principal instrument-makers of this ' city the knowledge they had acquired ' from

‘ from him*.’ Now such scholars, as it is easy to imagine, soon advanced beyond their masters, and completed reflectors by other and better methods than what had been taught them.

CERTAIN it is, at least, that Mr. JAMES SHORT, as early as the year 1734, had signalized himself at Edinburgh by his work of this kind. The excellent MACLAURIN, my dear departed friend, wrote that year to Dr. JURIN, ‘ that Mr. SHORT, ‘ who had begun with making glass *specula*, ‘ was then applying himself to improve the ‘ metallic ; and that, by taking care of the ‘ figure, he was enabled to give them ‘ larger apertures than others had done ; ‘ and that, upon the whole, they surpassed ‘ in perfection all that he had seen of ‘ other workmen.’ He added, ‘ that Mr. ‘ SHORT’s telescopes were all of the *Grego-*

* SMITH’S Syft. of Opt. b. iii. ch. 2.

‘ *rian* construction ; and that he had much
 ‘ improved that excellent invention*.’ This
 character of excellence Mr. SHORT maintained to the last, and with the more facility, as he had been well grounded both in the geometrical and philosophical principles of optics, and upon the whole was a most intelligent person in whatever related to his profession. It was supposed he had fallen upon a method of giving the parabolic figure to his great speculum ; a point of perfection that GREGORY and NEWTON had wished for, but despaired of attaining ; and that HADLEY had never, as far as we know, attempted, either in his *Newtonian* or *Gregorian* telescope. Mr. SHORT, I am well informed, said he had acquired that faculty, but never would tell by what peculiar means he effected it ; so that the secret of working that configuration, what-

* SMITH’S Syst. of Opt. b. iii. ch. 2. Rem. on art. 489.

ever it was, as far as it then appeared, died with that ingenious artist.

IT is Mr. MUDGE, therefore, who hath truly realized the expectation of Sir ISAAC NEWTON; who, above an hundred years ago, prefaged that the public would one day possess a parabolic speculum, ‘ not accomplished by mathematical rules, but by mechanical devices.’

THIS was a *desideratum*, but it was not the only want supplied by our worthy brother: he has taught us likewise a better composition of metals for the *specula*, how to grind them better, and how to give them a finer polish; and this last part (namely the polish), he remarks, was the most difficult and essential of the whole operation. In a word, I am of opinion, there is no optician in this great city (which hath been so long and so justly renowned for inge-

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nious

nious and dexterous makers of every kind of mathematical instruments), so partial to his own abilities as not to acknowledge, that however some parts of the mechanical process now disclosed might have been known before by individuals of the profession, yet that Mr. MUDGE hath opened to them all some new and important lights, and upon the whole hath greatly improved the art of making reflecting telescopes.

To enter into the detail of the ‘ devices’ (to use NEWTON’s expression), by which Mr. MUDGE hath arrived at the true parabolic figure, as well as at the other perfections of this instrument, would encroach too much on your time ; and, I may add, would not be altogether suitable to the present occasion. I have laid before you the sum of what he hath performed, and declared to you the opinion of your Council, that without his interposition the nicety of

the art was in danger of being lost ; or, at best, of being kept in the hands of those who were not likely to make it public. The character which Mr. MUDGE bears for integrity, would leave us no room to doubt of his being himself persuaded, that he hath in every point brought the great speculum of reflecting telescopes to that degree of perfection which he professes : but as authors and improvers, like parents and preceptors, can rarely divest themselves of too partial a fondness for what is their own, or amended by them, it will be satisfactory for you to know, that some of our brethren, the most intelligent in these matters, have frequently discoursed with Mr. MUDGE upon this subject ; have seen him at work upon the *specula* ; nay, have examined two reflecting telescopes (the one of 18 inches, the other of 22) completed by him ; and that they are confident he hath by no means exaggerated either what he

hath recovered to the body of arts, or what he hath added to it.

NEED I now set forth the merit of ascertaining and advancing the construction of the reflecting telescope, to an audience so well apprized of its value? To you, who know that of all inventions there are none so justly entitled to our admiration as those which have been fallen upon for enlarging the powers of vision; and that the discovery of optical instruments may be esteemed among the most noble, as well as among the most useful gifts, which the Supreme Artist hath conferred on Man? For all admirable as the eye came out of the hands of Him who made it, yet no organ of the animal frame hath He permitted so much to be assisted by human contrivance, not only for the uses and comfort of common life, but for the advancement of natural science; whether by giving form and proportion

portion to the minute parts of bodies (as it were to the atoms of Nature) imperceptible before; or by contracting space, and, as by magic art, bringing to view the grander objects of the universe, the immense distances of which had either disguised their aspect, or rendered them quite invisible!

IF PLINY, in regard to HIPPARCHUS, could extravagantly say, ‘ *Aufus rem Deo improbam annumerare posteris stellas!*’ what would that pompous historian of Nature have said, had it been foretold him, that in the latter days a man would arise, who should enable posterity to enumerate more new stars than HIPPARCHUS had counted of the old; nay, who should in a manner verify the vulgar notion of their being innumerable! who should assign four Moons to Jupiter, and in our Moon (supposed by many to have a smooth and polished surface) point out higher mountains

than any here below ! who should, in the Sun, the fountain of light, discover dark spots as broad as two quarters of the earth, and by these spots ascertain his motion round his axis ! who, by the varying *phases* of the planets, should compose the shortest and plainest demonstration of the truth of that system, till then the greatest of paradoxes, which supposed that the earth and planets revolved about that luminary* ! Yet these were but a part of the annunciations to the world of a single person, of GALILEO of unperishing memory ! To him his contemporary, and rival in fame Lord BACON, ascribed the invention of the *perspicilla* (for so they called at first the telescopes), and in a figurative strain thus expressed himself concerning them : ‘ With these (*perspicilla*), which GALILEO by a memorable effort of genius hath discovered, we are enabled, as with some

* GALILEI Sidereus Nuncius, sparsim.

‘ small

‘ small sailing vessels, to open and keep up
 ‘ a nearer commerce with the stars*.’

NOR did this celestial commerce cease with the acquisitions of GALILEO, but hath been extending ever since the time that that great man first turned his glasses to the heavens. The famous KEPLER, on the first notice, embraced the discovery, and, in 1611, the year following the *Sidereus Nuncius* of GALILEO, published a treatise of dioptrics, geometrically explaining the performance of the *perspicilla*, and proposing some proper improvements of them. Then came SNELLIUS, DESCARTES, and other celebrated geometers abroad, who applied themselves to optics, and successfully cultivated that fruitful branch of science. But whilst, at that period, in different parts of Europe, men of the first

* Quæ (perspicilla) memorabili conatu adinvenit GALILEUS, &c. Nov. Organ. l. ii. aphor. 39.

rank in mathematical studies seemed to vie with each other in promoting not only the theory of vision, but the mechanical practice of the instruments appertaining to it, and particularly the telescope; how did it happen, that, in this country, in the last century, which had so auspiciously begun with the lights derived from Lord BACON and Dr. HARVEY, we should afterwards find few traces of any attempt in that way earlier than the establishment of this Society? Of this pause in the course of your philosophical discoveries, the distracted state of these kingdoms, under a long civil war, was indubitably the occasion. For no sooner had we sheathed the bloody sword, and displayed the peaceful olive, than arts and sciences again sprang forth, and with so much vigour, that the advancement made, in these lands, since that epoch, in optics alone, may be considered as one of the noblest

noblest exertions of the human genius. Not to contend for a general superiority in the publications here on that subject, since the time that GREGORY entered first into that grand career, to silence all competition, I need but mention the *Theory of Light and Colours*; a piece so excellent for invention, for judgment in conducting experiments, and for drawing the proper conclusions from them, that, had it been NEWTON's single work, it would not only have done lasting honour to himself, but to the country that gave him birth. And as to the instruments, which of them, let me ask, hath not been either found out, or signally improved, among you? Or what nation is there that hath embraced the arts, and doth not value itself on possessing every piece of this kind of British workmanship? The reflecting telescope I may call wholly yours, both as to the original contrivance,

contrivance, and every step of its advancement: nay, from its revival by Mr. HADLEY to this day, a space of nearly threescore years, we have heard of no artist, out of this island, who hath been able tolerably to copy, much less to add to, this splendid invention.

WHAT acknowledgements, then, GENTLEMEN, do we not owe to our worthy Brother, who, for above twenty years past, in the uncertain intervals of a toilsome and anxious profession, hath unbent his mind, not in the perishing recreations of the world, but in investigating, with unremitting diligence, what had been done but concealed by others, and in making many successful experiments towards perfecting this inimitable instrument! A liberal account of these leisure hours he hath laid before you in his instructive Paper: a communication, I am persuaded,
that

that will not only preserve, but signalize his name in your records, among the very intelligent and ingenuous promoters of the great ends of your institution.

1872

Received of the Hon. Secy of the Navy
the sum of \$100.00 for the
purchase of the book "The
History of the United States
Navy" by John D. Lamberton

for the use of the
Library of the
Department of the Navy

at the rate of \$1.00 per copy
for the purchase of 100 copies

of the book "The History of the
United States Navy" by John D. Lamberton

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Library of the
Department of the Navy

A
D I S C O U R S E
ON THE
THEORY OF GUNNERY;

DELIVERED AT THE
Anniversary Meeting of the ROYAL SOCIETY,
November 30, 1778.

By Sir JOHN PRINGLE, Baronet.

PUBLISHED BY THEIR ORDER.

A

D I S C O U R S E

ON THE

THEORY OF GUNNERY.

GENTLEMEN,

AMONG the several experiments communicated to the Society, during the course of the preceding year, none seeming so much to engage your attention, as those contained in the Paper, intituled, *The Force of fired Gun-powder, and the initial Velocity of Cannon-balls, determined*
by

by *Experiments* : with much pleasure therefore I acquaint you, that, on account of the pre-eminence of that communication, your Council have judged the author, Mr. CHARLES HUTTON, worthy of the honour of the annual Medal, instituted on the bequest of Sir GODFREY COPLEY, Baronet, for raising a laudable emulation among men of genius, in making experimental enquiries. But, as on former occasions, so now, your Council, waving their privilege of determining the choice, have acted only as a select number deputed by you, to prepare matters for your final decision. I come, then, on their part, briefly to lay before you the state of the *Theory of Gunnery*, from its rise to the time when its true foundation was laid, in order to evince how conducive those experiments may be to the improvement of an art of public concern, as well as to the advancement of Natural Knowledge, the great object of
your

your institution. And if, upon a review of the subject, you shall entertain no less favourable an opinion of Mr. HUTTON's performance, than what your Council have done, it is their earnest request that you would enhance the value of this Prize, by authorizing your President to present it to our ingenious Brother in your name.

ARTILLERY (in the large acceptation of the term) took place long before the invention of gun-powder. We trace the art to the remotest antiquity, since the Sacred Records acquaint us, that one of the kings of Judah, eight hundred years before the Christian æra, erected on the towers and bulwarks of Jerusalem engines of war, the contrivance of ingenious men, for shooting arrows and great stones for the defence of that city*. Such machines were afterwards known to the Greeks and Ro-

* 2 Chron. xxvi. 15.

mans by the names of *balista*, *catapulta*, and others, which had amazing powers, and were not less terrible in their effects than the cannon and mortars of the moderns. It appears that the *balista* was contrived to shower volleys of darts and arrows of a very large size upon the enemy; whilst the *catapulta*, or *onagra* (as it was otherwise called), was fitted not only for that purpose, but for discharging stones of an enormous weight; I might say *rocks*, since some of them are reported to have weighed several hundred pounds. Batteries composed of numerous pieces of that kind of artillery, nothing could withstand. Yet, if we are rightly informed, their sole principle of motion consisted in the spring of a strongly-twisted cordage, made of animal substances singularly tough and elastic. These warlike instruments continued, not only during the time of the Roman empire, but to the twelfth and thirteenth centuries,

turies, as we find from history ; nor indeed is it probable that they were totally laid aside, till gun-powder and the modern ordnance, attaining a good degree of perfection, superseded their use. The very intelligent commentator of POLYBIUS* is of opinion, that the military art rather lost than gained by the exchange of the *cata-pulta* for the mortar : but, however that point may be determined in speculation, it is not likely that the ancient *tormenta militaria* will ever be revived ; but that all nations will keep to the art of gunnery, and study how to improve it ; that is, they will adhere to a system of artillery, wherein the moving power depends on the expansive force of gun-powder, or of some other substance of a similar nature.

UPON the first application of this principle to the purposes of war, nothing per-

* M. FOLARD.

haps was less thought of than to assist so empirical a practice by scientific rules ; for, however aiding in these matters the ancient mechanicians might have been, who, like ARCHIMEDES, had invented or perfected some of the *balistic* machines, no praise seemed now due to the mathematicians for either the discovery or improvement of the new artillery. In fact, we find the practice of the art had subsisted about 200 years, before any geometer considered it as one that admitted a theory, or at least such a theory as was grounded on geometry.

IT seems but just to trace and commemorate the inventors of the ingenious arts which furnish matter for discourses on these occasions ; and not only the main inventors, but even those who first turned their thoughts upon the subject : for, though such men may not have produced any thing perfect, yet they may have suggested

gested ideas to others of a less inventive, but of a more executive genius, and who, unprovided with these hints, would never have made any notable discovery. I must therefore observe, that the Italians were the first who emerged out of those thick clouds of ignorance and barbarism which had so long overspread this quarter of the world. They profited by the unhappy fate of Constantinople ; for, by liberally receiving the learned emigrants on that distressful occasion, they were largely repaid by their arts and sciences, and still more abundantly by their language, whereby they were enabled to read and to translate those ancient manuscripts, which the Greeks had saved out of the wreck of their country. The art of printing, which was established soon after, was the means of quickly disseminating those treasures of knowledge, and concurred with the fall of the eastern empire, to form an epoch for the advancement of

learning, unparalleled in the annals of letters.

THE end of the fifteenth century, and the whole of the sixteenth, were chiefly employed by the Italians in the study and in the translation of the old Greek authors. The geometry of the ancient Greeks, as well as the arithmetic in numbers and species of the Arabians, was cultivated; but both remained, as it were, sciences by themselves, unassisting to, or at best but weak and reluctant auxiliaries to, the philosophy of the schools: and indeed how could the abstracted doctrines of numbers and quantities be strained to co-operate with a system, in which neither the laws of motion, nor any but the superficial, and often delusive properties of matter, were to be met with? The genius of the Greeks, all acute and brilliant as it was, had never been properly directed to the interpretation
of

of Nature, and was indeed unfit (as Lord Bacon pronounced) for a study that made so slow and painful a progress, by reiterated and varied experiments and observations. It was no wonder, then, if the *Mixed Mathematics*, as they are called, descended to the moderns in a state no wise corresponding to the elegance and certainty of those parts of the science which were elementary and pure ; and that those mixed parts should have been found defective and erroneous, in proportion (if I may so express myself) to the physical considerations that were to be taken into the enquiry. The imperfection of the ancients, with regard to natural philosophy, was not perceived at that time : nay, at the period we are treating of, the learned were firmly persuaded of the contrary, and that all that was wanting to be known concerning the laws of Nature, and the properties of matter, was to be taken, either directly or by

deduction, from the physics of ARISTOTLE. It was not till the seventeenth century was somewhat advanced, that men of science began to listen to Lord BACON and GALILEO, the great founders of the experimental and the true philosophy.

MEAN while, in the beginning of the sixteenth century, unqualified as the Italians then were for entering upon physico-mathematical enquiries*, they nevertheless made the attempt, and in particular took the theory of projectiles into consideration. Some imagined that a body impelled with violence, such as a ball discharged from a cannon, moved in a right line till the force was spent, and that then it fell in another

* The chief exception that occurs to this general remark, is the rapid progress which in that age COPERNICUS made in astronomy; who was not indeed an Italian, but was supposed to have profited by his early travels into Italy, which he enlightened afterwards by his admirable discoveries.

right line perpendicularly to the earth. Upon this principle, absurd as it was, we find one of the earliest authors grounding his whole theory of gunnery^{*}; whilst others, dissenting from his hypothesis, admitted only the straight line, in which the ball moved for some time after coming out of the piece, and that other straight line in which it fell to the ground; but asserted that these two were connected by a curve line, and that this curve was the segment of a circle. NICOLAS TARTAGLIA of Brescia, a mathematician of the first rank in those days, and still celebrated for his improvements in algebra, hath been supposed to be the author of this doctrine, no less erroneous than the former, and for which two of his books have been quoted †.

* See MONTUCLA, *Hist. des Mathem.* vol. i. p. 623.

† Those were *La Nuova Scientia*, and *Questi ed Inventioni diverse*.

These I have never seen ; but, from another of his works, professedly written on this subject, and translated into English under the title of *Colloquies concerning the Art of Shooting in great and small Pieces of Artillery**, I find him, contrary to the opinion of his contemporaries, maintaining that no part of the track of a cannon-ball is in a right line, though the curvature in the first part of its flight be so small, that it needeth not to be attended to. But TARTAGLIA is far from supposing, that the line in question hath any relation to a *parabola*, or to any regular curve. It would seem, then, that if this mathematician had at first been so far mistaken, as to fancy that some part of the course of a projectile was in a straight line, he had afterwards changed his opinion, and was perhaps singular in what he finally embraced.

* Published at London, A. 1588.

FROM numerous instances one would imagine, that, in those days, so far were men of science from making experiments themselves, that they even shut their eyes against what chance would have presented to their sight. For, whoever had minded the roving shot of an arrow, the flight of a stone from a sling, or had attended to a stream of water issuing from the spout of a cistern, might have been convinced, that the path of every projectile was in a continued curve, whatever little he otherwise knew concerning the properties of that one.

BUT had the observation of the philosophers gone so far, they had still been at a distance from the truth. They might have perceived a likeness between the track of those bodies in motion and a parabola, and concluded, from analogy, that all projectiles delineated that curve in the air; but
they

they could never have realized their conjectures by mathematical demonstration, without previously knowing the law of *acceleration* in falling bodies : a discovery reserved for the next century, and for GALILEO*, one of the greatest ornaments of it.

IT was he who first investigated the effects of *gravity* on falling bodies, and upon that foundation demonstrated, that all projectiles would move in a parabola in a non-resisting medium. And, as he made little account of the resistance of the air, the properties of which were then imperfectly known, he proved that a ball shot horizontally would, in its flight, describe half a parabola ; and, when the piece had an elevation above the horizon, the ball would de-

* He was born in the year 1564 ; but few if any of his works were published till after the year 1600, and his Dialogues on Motion not before 1638.

scribe a whole parabola, supposing it to fall on the plane of the battery. By the same method of reasoning he shewed, that whatever the ranges of the projected body, or the elevations of the piece, were, the ball would still trace that curve line, of a greater or lesser amplitude, by the time it descended to the level of the place from whence it came.

THUS far went GALILEO, confining his projections to the horizontal plane of the battery: but TORRICELLI, his disciple, soon after carried the theory farther, by tracing the shot to its fall, whether that place was above or below the plane; and still found, by geometrical deductions, that it flew in a parabola of a larger or a smaller amplitude, according to the angle of elevation of the piece, and the strength of the powder.

VARIOUS and numerous had been the disputes in Italy about the laws of motion in general, and especially about those of projectiles, from the time the mathematicians had begun the enquiry, till the publication of the Dialogues of GALILEO on that subject (a space of upwards of a hundred years); but, from that period, so evident did his demonstrations appear, that all contest ceased, and every man of science was convinced, that all projectiles moved in the track which he had discovered. For, as to the resistance of the air, which he had not passed unnoticed (as GALILEO himself had been the first, at least of the moderns, who started the notion of the weight of the air and the pressure of the atmosphere), yet so thin and so yielding did they esteem that fluid to be, that they were assured it could occasion no sensible, at least no material, deviation from that curve. As they had the principle from
 GALILEO,

GALILEO, so they believed themselves warranted by that respectable author, not to fear, from that cause, any objection which he himself had suggested, but had removed. ‘ Among these projectiles,’ says he, ‘ which we make use of, if they are of
 ‘ a heavy matter and a round form ; nay,
 ‘ if they are of a lighter matter, and have
 ‘ a cylindrical form, such as arrows shot
 ‘ from bows, their track or path will not
 ‘ sensibly decline from the curve of a parabola *.’

HERE then was the theory of gunnery laid, in appearance, on the most solid foundation. And thus far the Italians having proceeded, they seemed to have taken leave, and to have committed the subject to other nations, whose greater power, or greater ambition, was more likely to make them avail themselves of the perfection of

* See his fourth Dialogue on Motion.

a military art, than their instructors. We had reason, therefore, to expect, that a neighbouring state, intent upon the advancement of the arts and sciences in general, would not fail to give particular attention to those that should appear most subservient to its grandeur. Accordingly we find, that our sister Society of that kingdom had not been many years established, when an ingenious Member of that illustrious Body, not questioning the soundness of the *Galilean* principle in regard to projectiles, in the year 1677 proposed to the academy, as a problem for the improvement of artillery, how to direct a piece (suppose a mortar) so as to make the shot fall where one had a mind; or, in the common expression, *to hit a mark*, the strength of the powder being given*. This thought met with general approbation, and so far

* See Hist. de l'Academ. Roy. des Sciences, A. 1707.

were

were the academy from raising any difficulty about the obstruction which the air might occasion to a body moving with so much velocity in it, that we do not find the making experiments on that head was considered by them as an essential step to the solution; but that their principal geometers straightway set about solving the problem as it had been announced to them, some following one method, some another, and all upon the supposition of a projectile moving in the line of a parabola. But M. BLONDEL, who had been the proposer, and who more particularly had studied the question, composed a large volume on the subject, which he published a few years after*, under the title of *L'Art de Jetter les Bombes*; a performance much celebrated at the time, and that continued in no small request long after, as containing, besides

* In the year 1683. See Hist de l'Acad. R. des Sci. A. 1707.

his own, the labours of several other Members of that Society of the most distinguished merit. So many and such hands concurring in framing this work, it was no wonder that the learned throughout Europe were confirmed by it in the *Galilean* theory; and the more, as M. BLONDEL had obviated the only objection they supposed could be made to it, the *resistance of the air*, which he had taken care expressly to mention, and so to combat as to persuade the reader, that the retardation arising from that cause was so inconsiderable as to be of no account in the practice.

THIS illusion about the small or non-resistance of the air to bodies rapidly moving in it, was so prevalent at the end of the last century, and in the beginning of the present, that, in the history of the Royal Academy for the year 1707, we find their worthy and most accomplished

Secretary,

Secretary, after taking notice of the joint labours of so many able mathematicians concerned in BLONDEL's publication, venturing to say, ' it did not appear that any thing was then wanting for the practice of the art (of Gunnery), except perhaps perfecting the instruments for pointing a cannon or mortar but that geometry had done its part, so to speak, with regard to practice, &c*.'

BUT far be it from our intention to relate the imperfections of others, in order to raise ourselves by the comparison. Candour requires of us not only to acknowledge that, in this country, as to the point in question, we did not surpass our neighbours; but ingenuously to own that, on the contrary, we were perhaps more liable to exception. For, some years before

* Hist. de l'Acad. R. des Sc. A. 1707, under the article *Mechanique*.

BLONDEL's work appeared*, a treatise was published by one of our own artilleryists, ANDERSON (a person of eminence in his profession), intitled *The genuine Use and Effects of the Gun*, in which the author strenuously supports the *Galilean* theory; nor do we learn that he was ever contradicted among us, although he undertook to answer all those who should make objections to it. Nay, when he had an opportunity afterwards of making experiments on the ranges of bombs, and by these trials was assured that their flight was not in a parabola; yet so far was he from ascribing the deviation from that figure to the resistance of the air, that he had recourse to an hypothesis, repugnant to all the laws of motion, to salve appearances, and to reconcile those experiments with his former doctrine†.

* Viz. in 1674.

† See his treatise *To Hit a Mark*, published in 1690.

AND did not Dr. HALLEY, so long the ornament of this Society, communicate, in the year 1686, a Paper, which he calls *A Discourse concerning Gravity*, in which, treating of the motion of projectiles, he says, that being aware of the deflection from the parabolic curve that might be occasioned by the resistance of the air, he had made some experiments, even with cannon-balls, to estimate the force of that resistance; yet conclude, ‘ that in large
 ‘ shot of metal, whose weight many thou-
 ‘ sand times surpassed that of air, and
 ‘ whose force is very great, in proportion
 ‘ to the surface wherewith they press there-
 ‘ upon, this opposition was not discern-
 ‘ ible.’ And again, ‘ though in small and
 ‘ light shot, the opposition of the air ought
 ‘ and must be accounted for; yet in shoot-
 ‘ ing great and weighty bombs, there need
 ‘ be very little allowance made; and so
 ‘ these rules (those, to wit, grounded on

‘ the principle of GALILEO) may be put
 ‘ in practice to all intents and purposes, as
 ‘ if this impediment (the resistance of the
 ‘ air) were absolutely removed*.’ Such
 conclusions, which we now find to be erroneous, were the less to be expected from so eminent a person, as they argued too much haste to finish a theory, that was to be made subservient to present use.

It might indeed have been expected, that men of science, applying themselves to this study, would have been sooner awakened to the consideration of the great opposition of the air, by the *Principia* of NEWTON, published a little after this Paper of HALLEY’s†. For in that excellent work the illustrious author had demonstrated, that the curve described by a projectile, in a strongly resisting medium, dif-

* Philos. Transf. No. 179, p. 20.

† In the year 1687.

ferred much from a parabola, and that the resistance of the air was great enough to make the difference between the curve of projection of heavy bodies and a parabola far from being insensible, and therefore too considerable to be neglected.

HAVE we not then less to plead for not attending to the *Principia* of NEWTON in this article*, than the mathematicians of other nations, who, as M. DE FONTENELLE observes†, partly from the difficulty of undertaking that concise and profound work, and partly from a misapprehension of its tendency (which they fancied was to revive the exploded doctrine of *occult qualities*), were late in becoming acquainted with it? But it is not so easy to account for their inattention to HUYGENS, a known and even then a much esteemed author,

* NEWTON, Princip. Mathem. lib. ii. sect. 7.

† Eloge de NEWTON.

and who indeed was second to NEWTON alone in science and in genius. For he, in the year 1690, had published a treatise on *Gravity*, written in a popular manner, wherein he gave an account of some experiments he had made at Paris, and in the academy, by which, as well as by mathematical investigations, he was convinced of the truth of NEWTON's conclusions, in regard to the great opposition of the air to bodies moving swiftly in it; and, by consequence, believed that the track of all projectiles was very different from the line of a parabola*.

BUT, excepting NEWTON and HUYGENS, the learned seemed universally to acquiesce in the justness and sufficiency of the principles of gunnery invented by GALILEO, enlarged by TORRICELLI, con-

* Discours de la Cause de la Pesanteur. Leide, 1690.

firmed and reduced to system by ANDERSON, BLONDEL, HALLEY, and others; and so far were the theorists, in that branch of science, from suspecting any defect or fallacy in these principles, that they seemed rather to reproach the practical artillerists, for not profiting more by the instructions which they had so liberally imparted to them. Nor do we find that an apology was made for the empirical exercise of the art, by any author of note in that line, earlier than the sixteenth year of this century, when M. DE RESSONS, a French officer of artillery, distinguished by the number of sieges at which he had served, by his high military rank, and by his abilities in his profession; when he, I say, thus qualified to bear testimony, presented a *Memoire* to the Royal Academy (of which he was a Member), importing, that ‘ although it was agreed that theory joined
 ‘ to practice did constitute the perfection
 ‘ of

‘ of every art, yet experience had taught
 ‘ him, that theory was of very little ser-
 ‘ vice in the use of mortars: that the work
 ‘ of M. BLONDEL had justly enough de-
 ‘ scribed the several parabolic lines, accord-
 ‘ ing to the different degrees of the eleva-
 ‘ tion of the piece; but that practice had
 ‘ convinced him there was no theory in
 ‘ the effects of gun-powder: for that, hav-
 ‘ ing endeavoured, with the greatest preci-
 ‘ sion, to point a mortar agreeably to those
 ‘ calculations, he had never been able
 ‘ to establish any solid foundation upon
 ‘ them*.’

THUS, after the theory of gunnery had
 exercised the genius of the learned for
 nearly two hundred years, and for almost
 fourscore of that time had rested on funda-
 mentals which had never been contested, it
 was pronounced at once to be almost en-

* Mem. de l’Acad. R. des Sc. A. 1716.

tirely useless, and that by one of the most competent judges. Now, whether it were owing to the deference due to the authority of that experienced artillerist, or to some other cause, I shall not determine, but observe, that it appears not from the history of the Academy, that the sentiments of M. DE RESSONS were at this time controverted, or any reason offered afterwards for the failure of the theory of projectiles, when applied to use. Nor can I pass unnoticed the pause that ensued before any farther attempts were made to improve the theory of the art, either upon the old principles or upon new ones, excepting by such authors as seemed ignorant of this transaction, and who of course were not sufficiently apprised of the inefficacy of the properties of the parabola, for directing practice: or by those who were employed in speculatively investigating the nature of the curve traced by a ball in the air; a
curve

curve which began at last to be considered as one deviating much from the line of a parabola: or, finally, by such as, having taken notice that NEWTON's ideas had not been duly attended to, endeavoured to avail themselves of them, and of some experiments that had been made by others, for proving the great opposition of the air to bodies of swift motion; but without ascertaining the degree of that resistance, or enriching the art by any practical rules*.

SUCH was the unhinged state of this part of the mixed mathematics, when, within our memory, Mr. BENJAMIN ROBINS took cognizance of it: nor could the subject have fallen into abler hands, endowed as he was by Nature with a superior genius and unwearied application. Mr.

* DAN. BERNOULLI, Comment. Acad. Petropol. T. 2. & 3.

ROBINS was deeply versed in geometry and the doctrine of numbers ; but he knew the limits as well as the powers of both, and how insufficient they were for establishing any theory where matter was concerned, without preparing the way, by finding out the physical properties of that *matter*, by many and varied experiments and attentive observation. Those who had hitherto treated of the foundation of gunnery, by being too forward in the application of their mathematics, had in a manner hurt the credit of that admirable science. They ought to have seen the necessity of minutely examining every circumstance which could affect the course of a projectile, besides that of gravity. Mr. ROBINS perceived the error of his predecessors in that enquiry, and corrected it. Persuaded as he was, from Sir ISAAC NEWTON's *Principia*, of the great resistance of the air to bodies moving in it, and also of

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the uncertainty of the force of gun-powder, and of the variations in the flight of shot, occasioned by the unavoidable varieties in the make of it, and in the make of the pieces of artillery which discharged it; apprised, I say, of so many causes of aberration, he justly concluded, that the foundation here was at least as much an affair of physics as of geometry, and that if the art of throwing bombs had not been advanced by theory, it was not because the art admitted of none, but because the theory which had hitherto been devised had been both defective and erroneous. He suspected that most of the writers on gunnery had been deceived, in supposing the resistance of the air to be inconsiderable, and thence asserting the track of all shot to be nearly in the curve of a parabola, by which means it came to pass that all their determinations about the flight of projectiles of violent motion, had declined considerably from the truth.

truth. But in order to clear this point from every doubt, he found it necessary to ascertain the force of gun-powder, and by that step to estimate the velocity of the shot impelled by its explosion. That being done, he proceeded to measure the quickness of a musket-bullet, shot out of a given barrel, with a given quantity of powder; and to confirm the truth of his conclusions, he contrived a machine, by which the velocity of a bullet might be diminished in any given *ratio*, by being made to strike on a large body of a weight justly proportioned to it; whereby the swiftest motions, which otherwise would escape our examination, were to be exactly determined by those slower motions that had a given relation to them. The machine was a large wooden pendulum, which swung freely, but in so slow a manner, that its vibrations could easily be counted, whatever was the celerity of the bullet discharged against it.

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The thought was simple, ingenious, and incontestably his own.

HE next enquired into the resistance made by the air to projectiles of rapid motion, and which he discovered to be much greater than had been supposed by any writer on the subject; and indeed so great, that it was manifest the curve described by any shot was very different from a parabola, and consequently that all the applications of the properties of that conic section to gunnery were so erroneous as to be totally useless. For, by means of this pendulum, placed at different distances from the mouth of the piece, he clearly demonstrated how much a bullet, flying with a given velocity, would gradually lose of that motion by the opposition of the air: therein furnishing to the learned a signal and instructive instance of the fallacy of the most specious theories, that
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do not proceed hand in hand with experiments.

I SHOULD too much exceed the just bounds of a discourse of this kind, were I to enter more minutely into the system founded by Mr. ROBINS, confirmed and improved, as I find, by the labours of several of the learned, in foreign parts, of great celebrity*. I shall only add, that his performance well deserves the title he gives it of *The New Principles of Gunnery*, since the author may more properly be said to have invented a new science than to have added to an old one. And I believe I may venture to say, that no physico-mathematical disquisition hath done more honour to this country, or to the age, than the writ-

* It is much to the honour of Mr. ROBINS, that his writings on this subject have been translated into foreign languages by men that were the best judges of their merit. I need only name M. M. EULER and LE ROY.

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ings of Mr. ROBINS on this subject, which have been published, partly by this Society, partly by himself, and partly since his death (in the collection of his whole mathematical tracts) by his learned friend.

BUT though our worthy Brother will ever be celebrated for having been the inventor of the true principles of gunnery, yet it would be too flattering to his memory, to say he had carried the theory of this art to perfection. He himself was far from entertaining so high an opinion of his labours: nay, he expressly declared, that he left some material points to be enquired into at more leisure (which other occupations, and his immature death, deprived him of); and he much regretted that he wanted conveniency and opportunities for making experiments on balls of a greater weight, than what he had used for ascertaining the initial velocity of them.

MUCH

MUCH therefore are we indebted to Mr. HUTTON, who, treading in the footsteps of the deceased, hath resumed and prosecuted this last *desideratum*, and hath shewn himself not unequal to so difficult an enterprise.

MR. ROBINS, for determining the initial velocity of shot, arising from different quantities of powder, made use of balls of about an ounce weight; whereas Mr. HUTTON, for the same purpose, hath employed those of different weights, from one pound to nearly three; or, in other words, Mr. ROBINS made trial with musket shot only, Mr. HUTTON with cannonballs from 20 to about 50 times heavier. This was a considerable step gained in a disquisition on that part of the science, in which the resistance of the air, and other circumstances, were not concerned; and where neither analogy alone, nor mathe-

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matical

mathematical deductions alone, nor the two combined, were sufficient for establishing principles applicable to the motion of cannonballs, without making a new series of experiments : and with what labour and judgment these have been performed, you understood by the account which Mr. HUTTON gave of them in his Paper.

BUT should it now be enquired, what advantages may be derived from Mr. HUTTON's experiments, for the advancement of the art of gunnery, and of philosophy in general ? I would reply, that, as to the former, it may be sufficient to observe, that though the improvements be only such as can be deduced from the force of fired gunpowder ; yet they are in a higher, more certain, and in a more general manner, than what resulted from the labours of Mr. ROBINS ; who indeed led the way, but who made, as it were in miniature, those experiments

experiments which Mr. HUTTON hath executed at large, and which Mr. ROBINS himself wished to have made, as well as others who have considered the subject since his time. Now these experiments, though made by Mr. HUTTON with cannon-balls of a small size, may nevertheless form just conclusions when applied to cannon-shot of the largest size. And such conclusions inform us of the real force of powder, when fired, either in a cannon or a mortar, impelling a ball or bomb of a given weight; that is, they discover with what velocity a given quantity of powder drives those projectiles in a second, or in any other assigned portion of time. They also shew the law of variation in the velocity, arising from different quantities of powder, with the same weight of metal, and likewise that law which takes place upon using balls of different weights. Farther, they point out the advantage obtained

by diminishing the windage in cannon, and teach us how we may increase the weight of the shot in the same piece, by making it of a cylindrical form, instead of a spherical: by this device, a smaller ship may be enabled to do the execution of a larger one. And experiments of the same kind will also determine the just length of cannon for shooting farthest with the same charge of powder.

LASTLY, it is from these experiments, or from others that may be made after the like manner, we are instructed how to answer every question relative to military projectiles, excepting such as depend on the resistance of the air to bodies moving swiftly in it. This indeed is a consideration which leaves room for greater improvement in the art, and for conferring fresh honours on those, who, like Mr. HUTTON, shall have opportunities and

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abilities

abilities for continuing and perfecting this very curious and useful enquiry.

As to the advantages accruing to philosophy from the labours both of Mr. ROBINS and Mr. HUTTON, speak they not for themselves? The sciences of motion and pneumatics are promoted by them; and of what avail their perfection would be for the farther interpretation of Nature, you need not be informed. In fine, we have here before us, in these experiments, the surest test of our advancement in true knowledge, which is, the improvement of a liberal art, and the enlargement of the powers of Man over the works of creation.

SOME, however, may think, that the objects of this Society are the arts of peace alone, not those of war; and that, considering how numerous and how keen the
instruments

instruments of death already are, it would better become us to discourage than to countenance their farther improvement. These naturally will be the first thoughts of the best disposed minds. But when, upon a closer examination, we find that, since the invention of arms of the quickest execution, neither battles nor sieges have been more frequent nor more destructive, indeed apparently otherwise; may we not thence infer, that such means as have been employed to sharpen the sword, have tended more to diminish than to increase the number of its victims, by shortening contests, and making them more decisive. I shall not however insist on maintaining so great a paradox; but only surmise, that whatever State would adopt the Utopian maxims, and proscribe the study of arms, would soon, I fear, become a prey to those who best know how to use them. For yet, alas, far seem we to be
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removed from those promised times, *when
nation shall not lift up sword against nation,
neither shall they learn war any more!*

MR. HUTTON,

YOU have heard, SIR, the account I have given of the rise and progress of the *Theory of Gunnery*, and of your improvement of it; a recital, which by no means would have done either you or the subject justice, had it been addressed to any other audience than to the present. But, as my intention was only briefly to recal to the memory of these gentlemen what they knew of this subject, antecedently to your Paper, and to remind them of the result of your experiments, I flatter myself I have said what was sufficient on the occasion: being now authorised by them to deliver
into

into your hand this Medal, as the perpetual memorial of their approbation. And let me add, SIR, that they make you this present with the more cordial affection, as by your other ingenious and valuable communications they are assured, not only of your talents, but of your zeal, for promoting the interests and honour of their institution.

F I N I S,

E R R A T U M.

In the title of the Discourse, On the Means of Preserving
the Health of Mariners, for 1775, read 1776.

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